United States
Department
Of Agriculture

Natural
Resources
Conservation
Service

SUPPLEMENTAL WATERSHED PLAN No. 6 & ENVIRONMENTAL ASSESSMENT

For Rehabilitation of the
Hop Brook Floodwater Retarding Dam
SuAsCo Watershed
Worcester County, Massachusetts

Prepared By:
U.S. Department of Agriculture
Natural Resources Conservation Service

DRAFT
April 2012

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Prepared By:
U.S. Department of Agriculture
Natural Resources Conservation Service

In Cooperation With:
Massachusetts Department of Conservation and Recreation
Worcester County Conservation District
Middlesex Conservation District
Massachusetts Division of Fisheries & Wildlife

AUTHORITY

The original watershed work plan was prepared, and works of improvement have been installed, under the authority of the Watershed Protection and Flood Prevention Act of 1954 (Public Law 83-566) as amended. The rehabilitation of the Hop Brook Floodwater Retarding Dam is authorized under Public Law 83-566 (as amended), and as further amended by Section 313 of Public Law 106-472.

ABSTRACT

The Hop Brook Floodwater Retarding Dam no longer provides the original protection planned for the watershed due to a greater than planned increase in development of the upstream drainage area. For current and future build-out development conditions, the dam does not meet current Massachusetts or Natural Resources Conservation Service design criteria for a high hazard dam. The local project sponsors have chosen to rehabilitate the dam to address the identified safety deficiencies. The purposes of the proposed rehabilitation of the Hop Brook Dam are to maintain the present level of flood prevention (flood damage reduction) benefits and comply with current performance and safety standards. Rehabilitation of the dam will require the following modifications to the structure: raise the existing earthen embankment and Dike A using a geocell wall, armor the existing auxiliary spillway with an articulated concrete block system, install a scour protection wall in the downstream exit channel of the auxiliary spillway, raise Dikes B and C with earthen material, and extend Dike C. Project installation cost is estimated to be $2,054,400, of which $1,340,258 will be paid from Small Watershed Rehabilitation funds and $714,142 from local funds.

COMMENTS AND INQUIRIES

For further information, contact Luis E. Laracuente, State Conservation Engineer, USDA/NRCS, 451 West Street, Amherst, MA 01002-2953, 413-253-4362.

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List of Acronyms

ACB	Articulated Concrete Blocks
APE	Area of Potential Effect
BVW	Bordering Vegetated Wetlands
BMPs	Best Management Practices
CEQ	Council of Environmental Quality
CFR	Code of Federal Regulations
Cfs	Cubic feet per second
CWA	Clean Water Act
DCR	Massachusetts Department of Conservation and Recreation
DEM	Massachusetts Department of Environmental Management
DEP	Massachusetts Department of Environmental Protection
DFW	Massachusetts Division of Fisheries and Wildlife
DWM	Massachusetts Division of Watershed Management
EAP	Emergency Action Plan
EPA	U.S. Environmental Protection Agency
FBH	Freeboard hydrograph
FEMA	Federal Emergency Management Agency
FWS	U.S. Fish and Wildlife Service
HUC	Hydrologic Unit Code
IDF	Inflow Design Flood
LUWB	Land Under Water Bodies
MassGIS	Massachusetts Geographic Information Systems
MEPA	Massachusetts Environmental Protection Act
NAAQS	National Ambient Air Quality Standards
NADVD88	North American Vertical Datum 1988
NED	National Economic Development
NHESP	Natural Heritage and Endangered Species Program
NOMM	National Operation and Maintenance Manual
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OARS	Organization for the Assabet, Sudbury, and Concord Rivers
O&M	Operation and Maintenance

P&G	Principles and Guidelines
PL	Public Law
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PSH	Principal Spillway Hydrograph
SCS	Soil Conservation Service
SDH	Stability Design Hydrograph
SHPO	State Historic Preservation Officer
SITES	Site Analysis Integrated Development Environment
THPO	Tribal Historic Preservation Officer
TMDL	Total Maximum Daily Load
TR	Technical Release
USACE	U.S. Army Corps of Engineers
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

CHANGES REQUIRING PREPARATION OF A SUPPLEMENT

INTRODUCTION

The Hop Brook Floodwater Retarding Dam (referred to hereafter as the "Hop Brook Dam" or the "dam") is one of ten floodwater retarding dams built between 1962 and 1987 in the watershed of the Sudbury, Assabet, and Concord Rivers (known as the SuAsCo watershed). One site, Constance M Fiske Dam in the Town of Framingham was singled out as the Baiting Brook Watershed Project. The remaining nine of those dams, including the Hop Brook Dam, were authorized to provide flood prevention (flood damage reduction) benefits in a 48-square-mile subwatershed by Natural Resources Conservation Service's (NRCS) 1958 *Watershed Work Plan for Watershed Protection and Flood Prevention, SuAsCo Watershed, Middlesex and Worcester Counties, Massachusetts* and five supplemental plans[1]. The Hop Brook Dam was constructed in 1964 in the Town of Northborough, Worcester County, Massachusetts (Figure 1, Appendix C-1). Figure 2 (Appendix C-1) depicts the existing conditions on an aerial photograph. The dam impounds Hop Brook, a tributary to the Assabet River, during rain events, but then slowly releases the water and has no permanent pool.

CHANGES IN THE WATERSHED

The Hop Brook Floodwater Retarding Dam (referred to hereafter as the "Hop Brook Dam" or the "dam") was built under the Watershed Protection and Flood Prevention Act of 1954 (Public Law (PL) 83-566[2]) for the purpose of flood prevention. The Hop Brook Dam was constructed in 1964 in a rural setting in the Town of Northborough, Worcester County, Massachusetts (Figure 1). Since 1964, urban development upstream of the dam has increased the quantity of stormwater runoff, and the 2005 Hop Brook Dam Assessment Report (NRCS 2005) determined:

> For current and build-out land use conditions the existing dam is overtopped by 1.4 and 1.6 feet respectively during the routing of the freeboard storm. The maximum permissible velocities are also exceeded in the auxiliary spillway.

As a result, the Massachusetts Department of Conservation and Recreation (DCR) applied to the NRCS in 2005 for funding assistance for rehabilitation of the dam to comply with current standards and ensure continued flood damage protection downstream of the dam.

In 2011, AMEC performed additional hydrologic and hydraulic modeling, and the results indicated that tailwater submergence conditions impede the passage of flow through the spillway system and contribute to overtopping of the dam during the routing of the freeboard hydrograph (FBH). These conditions also reduce the effectiveness of auxiliary spillway capacity improvements (i.e., widening, labyrinth spillway, etc.) to freely pass the FBH without overtopping the dam.

[1] The original Plan and the first four supplements were prepared by the Soil Conservation Service, which was the former name of the NRCS.
[2] As amended by PL 106-472, November 9, 2000.

CHANGES PROPOSED BY THE SUPPLEMENT PLAN

As a result of greater than expected increases in development within the watershed, the Hop Brook Dam no longer provides the flood protection benefits it was designed to provide. As such, improvements to the dam are proposed. Proposed improvements to the dam include:

- Raising the existing earthen embankment and Dike A with a geocell wall;
- Raising Dikes B and C using compacted earth fill;
- Extending Dike C to tie into natural high ground; and
- Armoring the auxiliary spillway with articulated concrete blocks (ACBs) and installing a scour protection wall in the downstream exit channel.

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SuAsCo Watershed
Worcester County, Massachusetts
3rd Congressional District

SUMMARY OF WATERSHED PLAN

Project Name: Rehabilitation of Hop Brook Floodwater Retarding Dam[3], SuAsCo watershed

Authorization: Public Law 83-566 Stat. 666 as amended (16 U.SC. Section 1001 *et. seq*.) 1954

Sponsors: Massachusetts Department of Conservation and Recreation
Worcester County Conservation District
Middlesex Conservation District
Massachusetts Division of Fisheries & Wildlife (DFW)

Description of the Preferred Alternative: The embankment and dikes will be raised to prevent overtopping and the auxiliary spillway will be armored for erosion protection. Raising the main embankment and Dike A would be accomplished using a geocell wall. The width of the embankment will remain the same. The auxiliary spillway would be armored with ACBs and a scour protection wall would be added to the downstream auxiliary spillway channel to prevent spillway erosion. Dike B would be raised using compacted earth material. Dike C would be raised using compacted earth material and would also be extended to the northwest to tie into higher ground. The principal spillway would not be affected by the project. The evaluated life of the rehabilitation structure is 54 years.

Resource Information:

Latitude and Longitude: lat. 42.295466 lon. -71.664350
8 Digit HUC Number: 01070005
Size of SuAsCo watershed: 241,000 acres (377 square miles)
Drainage area of Hop Brook Dam: 3,145 acres (4.91 square miles)

Climate (Worcester County):

Average annual precipitation: 49.2 inches
Average seasonal snowfall: 59.7 inches
Average winter temperature: 26.2 ºF Average winter daily minimum: 18.4 ºF

[3] Hop Brook Floodwater Retarding Dam is identified in the original SuAsCo Watershed Plan (SCS 1958). It is designated as dam A-3-c in the original work plan, as MA303 in the NRCS list of PL-566 dams, as 3-14-215-24 by the DCR Office of Dam Safety, and as MA00998 in the National Inventory of Dams database.

Average summer temperature: 67.7 ºF Average summer daily maximum: 76.9 ºF.
Average (50 percent) freeze-free period of 172 days: April 27 – October 16
Source: NRCS (2006)

Topography:

The SuAsCo watershed lies within an area of previous glaciation, and many glacial features are present. In addition, the watershed is characterized by the prevalence of swamps, ponds, and lakes. The drainage pattern is dendritic with many tributary streams. Within the SuAsCo watershed, the Assabet River has a steeper gradient than the lower Sudbury and upper Concord Rivers and as a result has a more rapid runoff of floodwaters (SCS 1958). Figure 1 depicts the site on a U.S. Geological Survey (USGS) topographic map.

Watershed Size:

Land use in Hop Brook Dam drainage area:

	Acres	% of drainage area
Agricultural	153	5
Forest	1,148	36
Developed, residential	1,538	49
Developed, commercial/industrial	57	2
Other (wetlands, open land, water, etc.)	249	8
Total	*3,145*	*100*

Land Ownership:

Hop Brook Dam drainage area:	Private 90 %	State-Local 10 %	Federal 0 %
Hop Brook Dam floodplain:	Private 78 %	State-Local 18 %	Federal 4 %

Number of farms (Worcester County): 1,547
Source: Massachusetts Farm Bureau (2002)

Average farm size (Worcester County): 69 acres
Source: Massachusetts Farm Bureau (2002)

Prime and important farmland:

	Drainage area (acres)	Floodplain (acres)
Prime farmland	813	284
Farmland of statewide importance	858	469
Farmland of unique importance	130	824
Total	*1,801*	*1,577*

Population and Demographics:

Project Beneficiary Profile: The primary beneficiaries of the project are residential, industrial, and commercial property owners in the floodplains of Hop Brook and the Assabet River; the towns of Northborough, Westborough, Berlin, Hudson, Stow, and Maynard; the City of Marlborough; and the Commonwealth of Massachusetts.

Characteristic	Northborough	Worcester Co.	Massachusetts	United States
Per capita income	$44,833	$29,316	$33,203	$26,059
Median annual household income	$102,969	$61,212	$62,072	$50,046
Median house value	$390,600	$268,100	$334,100	$179.900
Median age	42.5	39.2	39.1	37.2
Population	14,155	798,552	6,547,629	308,745,538
Population age 65 & over	12.9 %	12.8 %	13.8 %	13.0%
Unemployment rate	3.0 %	6.1 %	5.6 %	5.5 %
Poverty level	3.0 %	7.7 %	8.2 %	11.3%
Minority population	12.4 %	14.4 %	19.6 %	28 %

Source: 2010 U. S. Census Bureau (USCB) data.

Relevant Resource Concerns:

Wetlands: Estimated wetlands within the dry impoundment area, as interpreted and classified by the Massachusetts Department of Environmental Protection (DEP):

Wetland Type	Acres
Deep marsh	10.0 acres
Open water	0.7 acres
Shallow marsh, meadow, or fen	0.2 acres
Shrub swamp	4.1 acres
Wooded swamp deciduous	52.9 acres
Wooded swamp mixed trees	7.3 acres
Total	*75.2 acres*

A shrub swamp wetland of 2.6 acres lies just downstream of the dam. Permanent wetland impacts would occur along the downstream side of the auxiliary spillway where it is proposed to be widened and armored. Bordering vegetated wetlands (BVWs) would be impacted by the excavation and installation of ACBs and the scour protection wall; however the area would be restored and replanted with native wetland vegetation. The area of permanent wetland impacts would be less than one acre. Temporary wetland impacts (less than one acre) may occur at the toe of the slope of the dam as a result of construction access to embed the proposed armoring system. All temporary wetland impact areas would be restored following construction. All other construction staging and access would occur entirely within existing cleared or previously disturbed upland areas. All disturbed areas would be revegetated and restored after construction is complete. Figure 3 (Appendix C-1) depicts the DEP-mapped wetlands in the vicinity of the site.

Floodplains: Land uses within the 3,324-acre floodplain downstream of the dam:

	Acres	% of floodplain area
Agricultural	243	7
Forest	1,058	32
Developed, residential	312	9
Developed, commercial/industrial	297	9
Other (wetlands, open land, water, etc.)	1,414	43
Total	*3,324*	*100*

Highly Erodible Land:

Hop Brook Dam drainage area: 310 acres
Hop Brook Dam floodplain: 136 acres

Threatened and Endangered Species: No federally listed species are known to occur in the area. Habitat for the wood turtle (*Glyptemys insculpta*), a Massachusetts listed Species of Special Concern, occurs in the floodplain along Hop Brook, and the species has been documented within the Hop Brook Dam area as recently as 2007 according to the Massachusetts Natural Heritage and Endangered Species Program (NHESP) database. Wood turtles use a variety of riparian habitats but would be most susceptible to impacts when hibernating in the bottom of streams during the winter. Proposed activities would not occur within the stream. Figure 4 (Appendix C-1) shows NHESP-identified priority and estimated habitats for rare species in proximity to the site.

Cultural Resources: No historic properties that are listed on or eligible for listing on the National Register of Historic Places are present in the project's area of potential effect (APE). Construction will occur within the areas which have been previously disturbed as a result of dam construction.

Problem Identification: The Hop Brook Dam does not meet current dam design and safety criteria. Hydrologic and hydraulic modeling of the freeboard storm predicts that the dam would be overtopped by 0.99 and 1.12 feet for current land use and build-out conditions, respectively. Overtopping of the dam could lead to embankment erosion and dam failure. The models also predict that maximum permissible velocities for the auxiliary spillway would be exceeded, and erosion of the spillway slope could then occur. Dam failure from one or both of these causes would result in flood damages to approximately 901 residences, 71 non-residential properties, 120 roads, 1 school, 1 fire department, and 1 dam, plus utilities in the floodplain. Dam failure would also potentially cause the loss of life of residents, workers, or motorists.

Alternative Plans Considered:

Alternative 1 – Future without Project (No Federal Action Alternative)
The dam owner, DCR, has stated that it will rehabilitate the dam to meet current federal dam safety standards if federal funding assistance is not provided. DCR may choose to use rehabilitation methods other than those identified in this plan or develop its own plan to bring the dam into compliance with federal standards. As such, the dam will be rehabilitated regardless of any federal funding that may be provided under Alternative 2 below. From

herein, the "No Federal Action" Alternative shall be evaluated as the "No Action" Alternative.

Alternative 2 – Rehabilitation (National Economic Development (NED) Alternative)
The dam would be rehabilitated by raising the dam and Dike A elevations using a geocell wall system to an elevation of 313.6 feet (NAVD 88), armoring the auxiliary spillway with ACBs,installing a scour protection wall in the downstream exit channel, and extending Dike C to the northwest. Dikes B and C would be raised with compacted earth material. Federal funding assistance would be provided to the project sponsors by the NRCS. Drawing A-5 in Appendix C-2 depicts the NED alternative.

Project Purpose: Flood prevention (flood damage reduction). Rehabilitation of the Hop Brook Dam is necessary to meet current state and federal safety and performance standards.

Principal Project Measure: Rehabilitation of the dam involves four primary actions:

- Raising the earthen embankment and Dike A elevations to 313.6 feet NAVD88 using a geocell wall system.
- Armoring the auxiliary spillway with ACBs and the installation of a scour protection wall.
- Raising Dikes B and C to elevation 313.6 feet NAVD88 using compacted earthen material.
- Extending Dike C to the northwest.

Project Cost:

	PL 83-566[4] funds	Other funds	Total
Construction	$1,109,435	$586,156	$1,695,591
Engineering	$205,565	$0	$ 205,565
Technical assistance	$0	$0	$0
Relocation	$0	$0	$0
Real property rights	$0	$3,700	$3,700
Project Administration	$25,258	$13,601	$38,859
Permitting	$0	$110,685	$ 110,685
Total	$1,340,258	$714,142	$2,054,400
Annual O&M	$0	$6,000	$6,000

Project Benefits: Economic benefits of the project are derived from ensuring the continued flood prevention purpose of Hop Brook Floodwater Retarding Dam by meeting current performance and safety standards. Benefits are based on continuing flood prevention (flood damage reduction) to the downstream area, which has an annual benefit of $236,400. Rehabilitation would also minimize the risk of loss of life to residents and motorists traveling on downstream roadways within the breach flood area. Project benefits would continue to be derived through maintenance of wildlife habitat and groundwater recharge. Net average annual

[4] As amended by PL 106-472, November 9, 2000

equivalent benefits between the Future with Federal Project (Rehabilitation Alternative) and the Future without Federal Project (No Federal Action Alternative) = $0.

Identified Resource Concerns:

Concern	Degree of Concern	Degree of Significance to Decision Making
Dam safety	High	High
Human health and safety	High	High
Flood damages	High	High
Wetlands	Moderate	Moderate
Threatened & endangered species	Moderate	Moderate
Water quality	Moderate	Low
Fish habitat	Moderate	Low
Wildlife habitat	Moderate	Low
Prime farm lands	Moderate	Low
Highly erodible cropland	Moderate	Low
Cultural resources	Moderate	Low
Air quality	Low	Low
Water quantity	Low	Low
Aesthetics	Low	Low
Sedimentation and erosion	Low	Low
Recreation	Low	Low

Environmental Values Changed or Lost:

Resource	Impact
Air quality	Short-term impact from construction equipment emissions
Floodplains	Short-term impacts from construction equipment during the installation of the ACBs. The ACBs should not permanently negatively affect the floodplain.
Wetlands	No long-term impact; less than one acre of permanent wetland impacts; however area will be restored with native wetland vegetation. Potential temporary impacts to wetlands adjacent to construction area (less than 1 acre)—wetlands to be avoided if possible and restored with native vegetation if affected by construction
Fisheries	No effect; existing fisheries maintained
Wildlife habitat	No long-term effect (0 acres affected); temporary disruption near construction area (less than 1 acre)—disturbed areas would be replanted with native vegetation
Threatened and endangered species	No federally-listed species present. The wood turtle, a state-listed Species of Special Concern, has been identified in the vicinity of the project site; however, no activities are proposed in potential wood turtle habitat such as existing waterways or heavily vegetated banks.

Resource	Impact
Land use	No effect
Cultural resources	No effect
Prime farmland	No effect

Direct Beneficiaries:
Onsite: 0
Offsite: 31 residences, 33 non-residential properties, 61 roads, and 1 dam

Benefit to Cost Ratio:
Authorized Rate – Not yet determined
Current Rate – 4.00%

Funding Schedule: (2011-2016)
Federal Funds: $1,340,258
Non-Federal Funds: $714,142

Period of Analysis: 54 years

Evidence of Unusual Interest: There is no evidence of unusual Congressional or local interest in the project.

Major Conclusions: Rehabilitation of the Hop Brook Floodwater Retarding Dam is necessary to minimize the risk of loss of life and property damage within the potential breach area and to allow the continuance of flood prevention (flood damage reduction) benefits.

Areas of Controversy: There are no known areas of controversy.

Issues to be Resolved: None

Permits: The site-specific need for permits and mitigation will be determined during final design. The owner (DCR) will be responsible for obtaining the necessary local, state, and federal permits as the owner of the dam. Permits and consultation which will likely be required by the rehabilitation of the dam include:

(1) National Pollutant Discharge Elimination System (NPDES) general permit for construction,
(2) U.S. Army Corps of Engineers (USACE) permit under Section 404 of the Clean Water Act[5] of 1972,
(3) Chapter 253 Permit to Construct or Alter a Dam,
(4) Chapter 91 Waterways License,
(5) Order of Conditions through the Massachusetts Wetlands Protection Act[6],
(6) Section 401 Water Quality Certification,

[5] 33 U.S.C. §1251 *et seq*.
[6] 131 M.G.L. §40

(7) Section 7 U.S. Endangered Species Act[7] consultation with the U.S. Fish and Wildlife Service (FWS),
(8) Massachusetts Endangered Species Act[8] approval through Massachusetts NHESP, and
(9) Section 106 National Historic Preservation Act[9] consultation with the Massachusetts State Historic Preservation Office (SHPO) and the Tribal Historic Preservation Office (THPO) of with Wampanoag Tribe of Aquinnah.
(10) Massachusetts Environmental Protection Act (MEPA) review[10].

Is this report in compliance with executive orders, public laws, and other statures governing the formulation of water resource projects? Yes X **No**__

[7] 16 U.S.C. §1531
[8] M.G.L. c.131A and regulations at 321 CMR 10.00
[9] 16 U.S.C. 470 *et seq.*
[10] M.G.L. c. 30, sections 61 through 62H and 301 CMR 11.00

PURPOSE AND NEED FOR ACTION

The purpose of the project is to provide continued flood protection to downstream communities, residences, utilities, and to prevent the loss of the life. The proposed federal action is needed to meet current federal and stated dam safety guidelines and standards and to continue to reduce flood damages to 901 residences, 71 non-residential properties, 120 roads, 1 school, 1 fire department, and 1 dam, plus utilities in the floodplain downstream.

PURPOSE AND NEED FOR SUPPLEMENT

The purpose of the proposed dam rehabilitation project is to continue to prevent flood damages by complying with current performance and safety standards. Failure of the dam would cause serious damage to homes and commercial facilities downstream of the dam and potentially result in a loss of life. Rehabilitation of the dam is needed to continue to protect downstream properties, public utilities, highways, and a railroad and to reduce the risk of loss of life. Rehabilitation of the dam would extend the service life by 54 years and ensure the continued safe service of the dam throughout its original 100-year evaluation period.

This Supplemental Watershed Plan/Environmental Assessment was prepared to evaluate the rehabilitation of the Hop Brook Dam. The dam was built in 1964 in accordance with the 1958 SuAsCo Watershed Plan. An amendment to PL 83-566, the Watershed Rehabilitation Amendments of 2000 (PL 106-472), Section 313, authorizes funding and technical assistance to upgrade dams under the U.S. Department of Agriculture (USDA) Watershed Program. The rehabilitation upgrade of the Hop Brook Dam is authorized under this amendment. This supplemental plan documents the planning process by which the NRCS provided technical assistance to the local sponsors, technical advisors, and the public in addressing resource issues and concerns within the Hop Brook watershed. DCR cooperated in the preparation of the plan by leading the public meeting, reviewing technical studies (hydrology and hydraulic modeling, preliminary engineering), and reviewing the draft plan-environmental assessment.

WATERSHED PROBLEMS AND OPPORTUNITIES

The modeling results indicate that the auxiliary spillway does not meet all necessary design criteria for current land use and ultimate watershed build-out conditions. During a freeboard storm, pool elevation would overtop the dam by 0.99 feet under current conditions and 1.12 feet under build-out conditions, potentially leading to failure of the dam (AMEC 2011a). In addition, flow through the auxiliary spillway would exceed NRCS maximum permissible velocities, vegetative cover would likely fail, and headcut erosion would likely develop, contributing to the breach of the auxiliary spillway and potentially leading to failure of the entire dam.

The Hop Brook Dam provides approximately $236,400 in average annual flood damage reduction benefits for the Hop Brook watershed. The beneficiaries of the structure are the Commonwealth of Massachusetts and the localities of Northborough, Westborough, Berlin, Stow, Hudson, Maynard, and Marlborough.

Primary concerns are the safety of the dam and the potential problems that failure of the dam would cause. Associated downstream hazards include residential, commercial, and industrial developments, recreational facilities, secondary highways, and local roads, as well as utilities along those roads. Based on hydraulic modeling of the probable maximum flood (PMF) event, an uncontrolled breach of the Hop Brook Dam would cause flood damages to approximately 901 residences, 71 non-residential properties, 120 roads, 1 school, 1 fire department, and 1 dam, plus utilities in the floodplain. While the hydraulic model ends at the Washington Street Dam in the Town of Hudson, it is likely that during a PMF the dam would be overtopped and fail because it does not appear to have the hydraulic capacity to pass the PMF breach wave. Catastrophic failure of the Hop Brook Dam would also potentially cause the loss of life of residents, workers, and/or motorists Opportunities that would be realized through the implementation of this watershed rehabilitation plan are:

- Compliance with current dam safety criteria,
- Protection of human health and safety,
- Protection of infrastructure and transportation system,
- Maintenance of flood control benefits, and
- Prevention of increased flooding in the floodplain.

SCOPE OF THE PLAN

A scoping process was used to define project needs, determine important issues, and formulate alternatives. Scoping included a public meeting; written requests for input from state, local, and federal agencies; and coordination meetings with appropriate agencies. A steering committee of NRCS, DCR, and technical experts was also formed to assist in the formulation and evaluation of alternatives.

Stakeholder agencies that were contacted concerning the proposed project are:

Worcester County Conservation District
Massachusetts Department of Conservation and Recreation
Massachusetts Office of Dam Safety
Massachusetts Division of Fisheries & Wildlife
Massachusetts Department of Fish & Game, Riverways Program
Massachusetts Department of Environmental Protection
Town of Northborough (Selectmen, Conservation Commission, Planning Board, Engineering Department)
Town of Northborough Trails Committee
Organization for the Assabet, Sudbury, and Concord Rivers
Massachusetts Executive Office of Energy and Environmental Affairs
Massachusetts Executive Office of Energy and Environmental Affairs, Environmental Policy Act Office
U.S. Environmental Protection Agency (EPA) Region 1, Regulatory Section
U.S. Army Corps of Engineers, Regulatory Division
Massachusetts Historical Commission
Wampanoag Tribe of Gay Head (Aquinnah)

Table A presents the relevant resource concerns as a result of the scoping process. Table B summarizes the identified resource concerns applicable to the project through the scoping process.

TABLE A: RELATIVE RESOURCE CONCERNS

Item/Concern	Relevant to the Proposed Action?		Rationale
	Yes	No	
NED P&G	X		Alternative 2 (below) is the NED Alternative.
Air quality	X		Minimal, temporary impact
Coastal zone management areas		X	The project site is not located within a coastal zone management area
Coral reefs		X	There are no coral reefs in the vicinity of the project site.

TABLE A: RELATIVE RESOURCE CONCERNS			
Item/Concern	**Relevant to the Proposed Action?**		**Rationale**
	Yes	**No**	
Cultural resources	X		Analysis of effects required by National Historic Preservation Act; no historic sites present in APE
Dam safety	X		Primary concern of sponsors and NRCS
Ecologically critical areas		X	There are no ecologically critical areas in the vicinity of the site.
Endangered and threatened species	X		Analysis of effects required by Endangered Species Act; no federally protected species present. State-listed species (wood turtle) habitat occurs in project vicinity. Activities are not proposed for streams where nesting or hibernation occurs.
Environmental justice and civil rights	X		No impact. There are no Environmental Justice Zones within the project site.
Essential fish habitat		X	Massachusetts Dept of Fish and Game requested consideration of providing fish passage; project purpose does not include fish and wildlife habitat.
Fish and wildlife	X		Evaluated for all NRCS projects; minimal, temporary impact.
Flood damages	X		Primary concern of sponsors and NRCS
Forest resources	X		Minimal impact. Some clearing of second-growth forests may occur as a result from construction access.
Invasive species	X		Minimal impact. The area contains only limited areas with invasive species. Vegetated areas disturbed will be restored with native vegetation. Precautionary measure and best management practices will be utilized to reduce the risk of spreading invasive species to or from the site.
Land use	X		No impact. The land use of the area

TABLE A: RELATIVE RESOURCE CONCERNS			
Item/Concern	**Relevant to the Proposed Action?**		**Rationale**
	Yes	**No**	
			will not change as a result of the dam rehabilitation.
Migratory birds	X		Minimal, temporary impact.
National Parks, Monuments, and Historical Sites		X	There are no national parks or historical sites in the project area.
Natural areas	X		Minimal, temporary impact. After construction is completed, disturbed areas will be restored to their natural condition.
Parklands		X	There are no park lands in the vicinity of the project.
Prime and unique farmland	X		Evaluated for all NRCS projects; none affected by project.
Public health and safety	X		Primary concern of sponsors and NRCS
Regional water resource plans		X	There are no regional water resource plans in effect for the area.
Riparian areas	X		Minimal, temporary impact.
Scenic beauty	X		Minimal, temporary impact
Scientific resources		X	There are no scientific resources in the vicinity of the project area.
Sedimentation and erosion	X		Minimal temporary impact
Sole source aquifers		X	There are no sole source aquifers in the vicinity of the project area.
Social resources	X		Minimal, temporary impact
Soil resources	X		None affected by project.
Water quality	X		Minimal, temporary impact.
Water resources	X		No impact
Wetlands	X		Analysis of effects required by Clean Water Act and Executive Order 11990; potential for minor, temporary impact from construction; less than one acre permanent impact.
Wild and scenic rivers		X	There are no wild or scenic rivers in the vicinity of the site.

TABLE B: IDENTIFIED RESOURCE CONCERNS

Economic, social, environmental, and cultural concerns	Degree of Concern	Degree of Significance to Decision Making	Remarks
Dam safety	High	High	Primary concern of sponsors and NRCS
Human health and safety	High	High	Primary concern of sponsors and NRCS
Flood damages	High	High	Primary concern of sponsors and NRCS
Wetlands	Moderate	Moderate	Analysis of effects required by Clean Water Act and Executive Order 11990; potential for minor, temporary impact from construction; less than one acre permanent impact.
Threatened & endangered species	Moderate	Moderate	Analysis of effects required by Endangered Species Act; no federally protected species present. State-listed species (wood turtle) habitat occurs in project vicinity. Activities are not proposed for streams where nesting or hibernation occurs.
Water quality	Moderate	Low	Evaluated for all NRCS projects; minimal, temporary impact.
Fish habitat	Moderate	Low	Massachusetts Dept. of Fish and Game requested consideration of providing fish passage; project purpose does not include fish and wildlife habitat.
Wildlife habitat	Moderate	Low	Evaluated for all NRCS projects; minimal, temporary impact.
Prime farm lands	Moderate	Low	Evaluated for all NRCS projects; none affected by project.
Highly erodible cropland	Moderate	Low	Evaluated for all NRCS projects; none affected by project.
Cultural resources	Moderate	Low	Analysis of effects required by National Historic Preservation Act; no historic sites present in APE
Air quality	Low	Low	Minimal, temporary impact
Water quantity	Low	Low	No impact
Aesthetics	Low	Low	Minimal, temporary impact
Sedimentation and erosion	Low	Low	Minimal, temporary impact
Recreation	Low	Low	Minimal, temporary impact

AFFECTED ENVIRONMENT

The area potentially affected by rehabilitation of the Hop Brook Dam is the associated dike structures and the auxiliary spillway, the area adjacent to the dam that could be affected by construction, and the flood protection area downstream of the dam. The following discussions of existing conditions focus on these areas, plus the general project vicinity—the Town of Northborough—where appropriate.

EXISTING CONDITIONS

Original Project

The Hop Brook Dam was one of nine floodwater-retarding structures proposed in the 1958 SuAsCo Watershed Plan under the authority of PL 83-566[11]. The dam was constructed in 1964 with federal assistance provided by the USDA, Soil Conservation Service (SCS, now the NRCS). Subsequently five supplements to the original plan were prepared and approved between 1964 and 1996. The supplements occurred after construction of the Hop Brook Dam and were not concerned with this facility. Through these supplements, two of the original dams were deleted from the plan and three others were added, and as a result ten floodwater retarding structures were planned and constructed between 1962 and 1974 for watershed protection and flood prevention. The Middlesex Conservation District and the Northeastern Worcester County Conservation District were the original local sponsoring organizations. The three conservation districts in Worcester County have combined into one district, known as the Worcester County Conservation District. Through the supplemental planning process and reorganization of state agencies, by 1996 the local sponsoring organizations also included DFW and the Massachusetts Department of Environmental Management (DEM). Further state reorganizations since 1996 have resulted in renaming DEM as DCR.

Description of Existing Dam

The dam was originally designed and constructed as a federal ”high hazard” class dam, a hazard classification given to dams whose failure “may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railroads.” The floodwater retarding structure is comprised of six major elements: the earthen embankment or main dam, the drop inlet principal spillway, the auxiliary spillway, and three dikes referred to as Dike A, Dike B, and Dike C. Figure 2 presents a schematic drawing of the Hop Brook Dam. Drawings A-3 and A-4 in Appendix C-2 provide the Existing Conditions Engineering Plans.

The dam is located on the southeastern side of the impoundment area. The dam embankment has a total structural height of approximately 23 feet, a hydraulic height[12] of approximately 19 feet, and an overall length of approximately 410 feet. Under normal operating conditions, there is no impoundment upstream of the dam. During impoundment conditions, with the water level at the crest of the auxiliary spillway, the storage capacity of the dam is estimated to be 1,340 acre-feet,

[11] As amended by PL 106-472, November 9, 2000.

[12] Hydraulic height is defined as the difference between the elevation of the maximum controllable water surface elevation (auxiliary spillway crest) and the elevation of the lowest point in the original streambed.

which classifies the dam as a "Large" structure in the DCR Office of Dam Safety classification system[13].

The upstream slope of the dam is generally uniform with a slope of 3H:1V. The slope extends from the south abutment to the south side of the auxiliary spillway and is primarily grass covered. The top of the dam is approximately 12 feet wide and grass covered with an elevation of 312.3 feet NAVD88. The downstream slope also extends from the south abutment to the south edge of the auxiliary spillway and is primarily grass covered with an average slope of approximately 3H:1V. The downstream toe of the slope contains a rock toe drain that consists primarily of an approximately 12-foot-wide by 3-foot-high triangular section of embankment of coarse gravel and rock. A 27-inch reinforced concrete sewer main passes through the south side of the dam. Two relief wells are provided along the length of the connection ditch along the downstream right toe of the dam to convey water from the rock toe drain to the principal spillway stilling basin.

The principal spillway for the dam is located near the north end of the dam embankment. The structure consists of a reinforced concrete riser that leads to a 36-inch-diameter reinforced concrete outlet pipe. Normal flow of the brook enters the riser by means of a 30-inch-diameter opening that functions as the lower stage inlet set to elevation 291.3 feet NAVD88. Upstream of the orifice, a vertical steel slatted rack bolted to the low stage concrete headwall extends upstream of the concrete riser to prevent obstructions from entering the structure. Access to the interior of the intake structure is through a 24-inch-diameter manhole cover on top of the structure. The tops of the side walls of the riser are set to elevation 301.3 feet NAVD88 to act as overflow weirs during high stage impoundment levels, with the openings protected by galvanized steel pipe trash racks and a reinforced concrete anti-vortex cap. Three anti-seep collars are provided along the length of the outlet pipe to limit seepage along the pipe. The downstream end of the pipe is supported by a reinforced concrete cradle and bent constructed with a two stage filter upstream. The discharge at the downstream toe of the dam flows into a 36-foot-long rock riprapped trapezoidal stilling basin and then flows for a short distance through a 35-foot-wide man-made channel before joining the natural stream channel.

The auxiliary spillway is located north of the dam embankment and extends to the west end of Dike A. The auxiliary spillway is a grass lined channel with a crest elevation approximately 4 feet below the top of the dam (design elevation 308.3 feet NAVD88). The crest of the auxiliary spillway is 340 feet wide and 20 feet long. The upstream and downstream slopes of the auxiliary spillway are approximately 3H:1V and 5H:1V, respectively. Discharge through the auxiliary spillway would spread through the wetland area at the toe of the spillway prior to entering the downstream discharge channel.

The three dikes are located north of the auxiliary spillway. Dike A is approximately 740 feet long running in an easterly direction with a height that varies between a maximum of approximately 19 feet to a minimum of less than 2 feet. Dike B is located approximately 200 feet north of the east side of Dike A and runs for approximately 290 feet in a northerly direction with a maximum height of 15 feet. Approximately 600 feet north of the north end of Dike B, Dike C begins and extends north for approximately 925 feet with a maximum height of 15 feet.

[13] 302 CMR 10.00

The downstream slopes of the dikes are protected with rock toe drains to collect seepage. Seepage waters collected by the toe drain of Dikes B and C flow through separate culverts beneath Route 20, through a connecting ditch on the east side of the road, and through a culvert beneath Tomblin Hill Road before joining flows from the principal spillway at Smith Pond. Each of the three dikes is constructed of geometry similar to that of the dam embankment, with 3H:1V grassed slopes and a 12-foot-wide crest with a design elevation of 312.3 feet NAVD88.

In 2005 and 2008, the NRCS sponsored inspections of the Hop Brook Dam. The inspections determined that the dam is in good to satisfactory condition. The DCR is responsible for maintenance of the dam. As of July 2008, minor deficiencies identified in the 2005 inspection, including wear of vegetative cover and deterioration of the primary spillway trash rack had been repaired. There was no indication of major repairs or changes to the dam since the dam's 1964 construction (H&S Environmental 2009).

Existing Structural Data

Table C provides a summary of the existing structural data for the Hop Brook flood control structure.

TABLE C: EXISTING STRUCTURAL DATA – HOP BROOK FLOODWATER RETARDING DAM

Year completed	1964
Drainage area	3,145 acres (4.91 square miles)
Stream	Hop Brook
Purpose	Flood prevention
Dam type	Earthen embankment
Dam height	23 feet
Dam crest length	410 feet
Storage:	
Total, maximum pool	1,928 acre-feet
Total, auxiliary spillway crest	1,340 acre-feet
Sediment	22 acre-feet
Flood	1,318 acre-feet
Principal spillway:	
Type	Reinforced concrete
Lower stage inlet height	0 feet
Lower stage inlet size	30 inches
Upper stage inlet height	10 feet
Outlet conduit size	36 inches
Auxiliary spillway:	
Type	Grass-lined channel
Width	340 feet
Principal spillway crest elevation	301.3 feet NAVD88
Auxiliary spillway crest elevation	308.3 feet NAVD88
Top of dam (minimum crest) elevation	312.3 feet NAVD88

Dam Safety: Both the federal government, under the Federal Emergency Management Agency (FEMA), and the Commonwealth of Massachusetts, under the DCR, have developed specific dam safety criteria (FEMA 2004 and 302 CMR 10).

As previously discussed, the dam does not meet current dam design and safety criteria. As such, it no longer provides the flood prevention services it was originally designed for. The dam currently provides $236,400 of flood protection for the downstream communities. Failure of the dam would impact 901 residences, 71 non-residential properties, 120 roads, 1 school, 1 fire department, and 1 dam, and could result in the potential loss of life. Therefore, rehabilitation of the dam is necessary in order to bring the dam into compliance with federal and state dam safety guidelines and standards. Rehabilitation of the dam would conform to FEMA guidelines and the DEP standards for a high hazard dam and large structure, respectively.

Hydrologic and hydraulic modeling of the freeboard storm predicts that the dam would be overtopped by 0.99 and 1.12 feet for current land use and build-out conditions, respectively. Overtopping of the dam could lead to embankment erosion and dam failure. The models also predict that maximum permissible velocities for the auxiliary spillway would be exceeded, and erosion of the spillway slope could then occur. Dam failure from one or both of these causes would result in flood damages to approximately 901 residences, 71 non-residential properties, 120 roads, 1 school, 1 fire department, and 1 dam, plus utilities in the floodplain. Dam failure would also potentially cause the loss of life of residents, workers, or motorists. The Breach Inundation Zone maps provided in Appendix C-3 depict the residences and infrastructure that would be damaged as a result of dam failure.

Physical Features and Environmental Factors

Project Location: The Assabet River flows north for 30 miles to its confluence with the Sudbury River in Concord, Massachusetts, where the two rivers form the Concord River, which flows north for 15.5 miles to its confluence with the Merrimack River in Lowell, Massachusetts. The SuAsCo watershed encompasses a large network of tributaries that drain approximately 377 square miles in Middlesex and Worcester Counties. The watershed contains 25 tributary sub-watersheds, one of which is Hop Brook watershed. The drainage area for Hop Brook is approximately 3,145 acres (4.91 square miles) and extends through moderately developed areas within the Town of Northborough west of the dam and areas of residential development within the Town of Shrewsbury. Figure 1 in Appendix C-1 depicts the site on a USGS topographic map.

Climate: The average annual precipitation for Worcester County is 49.2 inches, and the average seasonal snowfall is 59.7 inches. In winter, the average temperature is 26.2 ºF, and the average daily minimum is 18.4 ºF. In summer, the average temperature is 67.7 ºF, and the average daily maximum temperature is 76.9 ºF. The average (50 percent) freeze-free period of 172 days extends from April 27 through October 16 (NRCS 2008a).

Geology and Soils: The project area is generally located at the boundary of the Nashoba Formation (OZn) of metamorphic rock and the Marlboro Formation (Ozm) of Mafic Rocks. The soils are generally described as Paxton-Woodbridge-Ridgebury banded with Merrimac-Hinckley-Windsor. Paxton-Woodbridge-Ridgebury soils consist of very deep, poorly drained

(Ridgebury) to well drained (Paxton) soils on glacial till uplands that formed in firm and very firm glacial till derived from schist, gneiss, and granite. Merriman-Hinckley-Windsor soils consist of very deep, excessively drained soils on outwash plains that formed in glacial outwash derived mostly from granite, gneiss, and schists. These soils are generally centered in the vicinity of the stream channels and extend through the area.

According to the NRCS soil survey for Worcester County, several major soil types are located within the area surrounding Hop Brook (SCS 1985). Richfield, Merrimac, Agawam, and Canton fine sandy loams comprise approximately 54 percent of the soils in the area around Hop Brook. Poorly drained Freetown muck accounts for 24.6 percent of the soil type around the Hop Brook Dam. Gravel pits and rocky outcrop complex account for an additional 13.7 percent of the major soil types.

The original design geology as interpreted from the boring logs provided on the as-built drawings indicated a variety of soil materials along the alignment of the dam and dikes. These materials varied from poorly graded sands to well graded silty sand and gravel. Although variation was observed across the site, all soils appeared to represent a granular type material with variable amounts of gravels and silts as is typical of the glacial history of the area (H&S Environmental 2009). Figure 5 in Appendix C-1 depicts the mapped soils in the vicinity of the dam.

Topography: The SuAsCo watershed lies within an area of previous glaciation, and many glacial features are present. In addition, the watershed is characterized by the prevalence of swamps, ponds, and lakes. The drainage pattern is dendritic with many tributary streams. Within the SuAsCo watershed, the Assabet River has a steeper gradient than the lower Sudbury and upper Concord Rivers and as a result has a more rapid runoff of floodwaters (SCS 1958). Figure 1 depicts the site on an USGS topographic map.

Prime Farmland: Prime farmland, as defined by the USDA, is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses. These soils can exist as cultivated land, pastureland, forestland, or other land, but they are not urban or built-up land or water areas (NRCS 2011). Prime farmland is protected by the Farmland Protection Policy Act in order to "minimize the extent to which Federal programs contribute to the unnecessary and irreversible conversion of farmland to non-agricultural uses" (NRCS 2008b).

Soils that are designated as prime farmland and are present in the Hop Brook Dam drainage area are the Agawam and Merrimac series fine sandy loams (NRCS 2007). Table D presents the acreages of soils in the Hop Brook Dam drainage area and the downstream floodplain that are designated as prime farmland, farmland of statewide importance, or farmland of unique importance. Figure 5 depicts the mapped soils in the vicinity of the dam.

TABLE D: IMPORTANT FARMLAND SOILS

Soil Designation	Drainage Area (acres)	Floodplain (acres)
Prime farmland	813	284
Farmland of statewide importance	858	469
Farmland of unique importance	130	824
Total	*1,801*	*1,577*

Source: MassGIS 2008b

Highly Erodible Land: Highly erodible land is described in 7 CFR Subpart B. In general, highly erodible land is classified as land that is highly susceptible to either wind or water erosion. As such, soils which have a high erodibility index are often categorized as highly erodible. As summarized in Table E, less than 10 percent of the Hop Brook Dam drainage area and less than 5 percent of the downstream floodplain are highly erodible lands.

TABLE E: HIGHLY ERODIBLE LAND

	Drainage Area		Floodplain	
Land Use	**Acres**	**Percent**	**Acres**	**Percent**
Highly erodible land	310	9.9	136	4.1
Potentially highly erodible land	865	27.5	426	12.8
Not highly erodible land	1,970	62.6	2,762	83.1
Total	*3,145*	*100*	*3,324*	*100*

Source: MassGIS 2008b

Water Quality: Water quality is generally described as the physical, chemical, and biological characteristics of water and the condition of that water to the requirements of a given organism. The Organization for the Assabet, Sudbury, and Concord Rivers (OARS) conducts monthly water quality monitoring of Hop Brook near Otis Street in Northborough. Data from the 2009 and 2010 field seasons are presented in Table F (OARS 2011a). OARS rated stream health in Hop Brook as "good" to "excellent" for 5 of the 8 weeks sampled in June 2009 to September 2010 (OARS 2011b). In its water quality assessment of the SuAsCo watershed, the Massachusetts Division of Watershed Management (DWM 2005) noted "some indications of water quality degradation in Hop Brook," mainly occasional low dissolved oxygen concentrations.

TABLE F: WATER QUALITY AND STREAM HEALTH, HOP BROOK, NOVEMBER 14, 2010

Parameter	Result[1]	Water Quality Standards
Total nitrogen	<0.05	0.71[2]
Total phosphorus (mg/L)	0.02	0.31[2]
Total suspended solids	7 mg/L	"Free from flowing, suspended and settleable solids in concentrations and combinations that would impair any use assigned to [Class B waters]"[3]
Dissolved oxygen (mg/L)	88.0	>5.0[4]
pH (SU)	6.88	6.5-8.3[4]
Water temperature (°C)	5.91	<28.3[4]
Streamflow (cfs)	7.75	n/a

Note: mg/L = milligrams/liter; cfs = cubic feet per second; ºC = degrees Celsius
[1/] OARS (2011b)
[2/]EPA (2000)
[3/]314 CMR 4.05 (b)(5)
[4/]310 CMR 4.05 (3)(b)

Hop Brook discharges into the Assabet River. The Massachusetts Division of Watershed Management (DWM) summarized water quality in the Assabet River (DWM 2005):

> Historically, wastewater discharges and water withdrawals for public supply have deleteriously affected the Assabet River. A nutrient total maximum daily load (TMDL) for the Assabet River was completed in 2004... Implementation of the TMDL requires removal of total phosphorus to 0.1 mg/L in the effluent of the major municipal wastewater treatment plants and evaluation of the feasibility of sediment remediation to reduce phosphorus flux from the sediments.

Rehabilitation of the Hop Brook Dam is not expected to have a significant adverse effect on water quality because it has no permanent impoundment.

Fish and Wildlife Resources: As a mostly developed area, wildlife resources expected to be associated with the area surrounding the Hop Brook Dam would be species tolerant of human activities such as small mammals (gray squirrel [*Sciurus carolinensis*], raccoon [*Procyon lotor*], striped skunk [*Mephitis mephitis*], Virginia opossum [*Didelphis virginiana*], and small rodents) and resident and migrant birds (great blue heron [*Ardea herodias*], mallard [*Anas platyrhynchos*], and Canada goose [*Branta canadensis*]).

Fish surveys conducted by the DFW at two stations in Hop Brook in 2001, downstream of the dam in Smith Pond, identified nine fish species, as listed in Table G. Banded sunfish (*Enneacanthus obesus*), bluegill (*Lepomis macrochirus*), and yellow bullhead (*Ameiurus natalis*) have been introduced into the Assabet River watershed and are now found in the Hop Brook.

The other species are native to the area. The DWM determined that the aquatic life use in the Hop Brook is supported based primarily on the benthic macroinvertebrate community analysis and excellent habitat quality conditions (DWM 2005). The benthos was classified as "slightly impacted…possibly as the result of the upstream impoundment [Smith Pond, which is downstream of Hop Brook Dam] and adjacent land uses." Hop Brook Dam is not expected to have a significant effect on aquatic life because it has no permanent impoundment.

TABLE G: FISH SPECIES OBSERVED AT THE HOP BROOK (SMITH POND) SITE

Common Name	Scientific Name	# Observed
American eel	*Anguilla rostrata*	2
Banded sunfish	*Enneacanthus obesus*	1
Blacknose dace	*Rhinichthys atratulus*	50
Bluegill	*Lepomis macrochirus*	1
Brook trout	*Salvelinus fontinalis*	7
Chain pickerel	*Esox niger*	3
Fallfish	*Semotilus corporalis*	7
White sucker	*Catostomus commersoni*	9
Yellow bullhead	*Ameiurus natalis*	2
	Total	82

Source: DWM 2005, OARS 2008

Threatened and Endangered Species: In response to a consultation request from NRCS, the U.S. Fish and Wildlife Service (FWS) stated that there are no listed or proposed threatened or endangered species or critical habitat in the project area (FWS 2011). A letter received from the Massachusetts NHESP in response to an information request stated that the wood turtle has been found in the vicinity of the project site as recently as 2007 (DFW 2011a). Estimated habitat for the wood turtle occurs both upstream and downstream of the dam (Figure 4). Copies of the "no species present" letter from the FWS and the NHESP response letter can be found in Appendix E-2.

In Massachusetts, the wood turtle is listed as a Species of Special Concern and is protected by the Massachusetts Endangered Species Act. According to NHESP data, wood turtle habitat includes slower moving, mid-sized streams with sandy bottoms and heavily vegetated banks. They overwinter in the stream bottom and muddy banks and nest in sand or gravel substrate near the edge of the stream. The remainder of the year they can utilize a variety of areas including mixed or deciduous forests, fields, riparian wetlands and wet meadows (DFW 2011b).

Wood turtles were not observed during recent site surveys. Vegetated areas immediately adjacent to the dam along Hop Brook appear to be regularly cut to prohibit the overgrowth of vegetation limiting the heavily vegetated banks preferred by the wood turtle. Possible wood turtle habitat was observed farther upstream and downstream of the dam consistent with the habitat delineated by Massachusetts Geographic Information Systems (MassGIS) NHESP data and outside of the potential construction area. Winter hibernation for wood turtles occurs in streams, and no activity related to the rehabilitation project is planned to occur in the stream below the dam.

Wetlands: A map of freshwater wetlands, as interpreted and classified according to cover type by the DEM using aerial photographs, was obtained from MassGIS data (Figure 3). Wetland types within the floodplain upstream of the dam are listed in Table H. A shrub swamp wetland of 2.6 acres lies just downstream of the dam.

TABLE H: MAPPED DEP WETLANDS

Wetland Classification	Area (acres)
Deep marsh	10.0
Open water	0.7
Shallow marsh, meadow, or fen	0.2
Shrub swamp	4.1
Wooded swamp deciduous	52.9
Wooded swamp mixed trees	7.3
Total	*75.2*

Source: MassGIS 2009a

Wetlands on both sides of the dam where project construction could be located were field-delineated (Figure 6, Appendix C-1). State-regulated wetland resources identified at the site, as defined in the Massachusetts Wetlands Protection Act Regulations[14], include BVWs, Banks, Land Under Water Bodies (LUWB), and Riverfront Area, as described below.

A BVW is located along the western and southeastern portions of the Hop Brook Dam, including Dikes A, B, and C. This BVW meets the definition of a Freshwater Wetland according to the Massachusetts regulations and, therefore, a 100-foot Buffer Zone is applied. The boundary of the BVW is situated either at the toe of slope associated with the fill area for the Hop Brook Dam or is located further downslope away from the dam itself.

The delineated portion of the BVW adjacent to the dam includes forested wetlands dominated by red maple (*Acer rubrum*) and white pine (*Pinus strobus*) and a small emergent wetland along Route 20 dominated by broadleaf cattail (*Typha latifolia*). Understory vegetation in this wetland consists of sweet pepperbush (*Clethra alnifolia*), winter berry (*Ilex verticillata*), arrowwood (*Viburnum dentatum*), reed canary grass (*Phalaris arundinacea*), sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnamomea*), and sphagnum moss (*Sphagnum* spp.). Soils are generally comprised of 6 to 20 inches of black (10YR 2/1) muck underlain by approximately 6 inches of black (10YR 2/1) mucky-sandy loam. The 100-foot Buffer Zone associated with the BVW at the site includes forested uplands and existing cleared or previously disturbed land associated with Hop Brook Dam.

Bank wetland resources immediately adjacent to the dam are limited to the banks of Hop Brook. The majority of the Banks on-site are vegetated and comprised of mineral soil material. Woody Bank vegetation includes red maple trees and sweet pepperbush, winter berry, and arrowwood shrubs. Emergent vegetation includes sensitive fern, cinnamon fern, and sphagnum moss.

[14] 310 CMR 10.00

LUWB immediately adjacent to the dam is limited to land under Hop Brook. This LUWB is generally comprised of mineral soil material.

Riverfront Area is defined as the area of land between a river's mean annual high water line and a parallel line measured 200 feet horizontally from this high water line. Hop Brook is defined as a river as it is a perennial body of water that empties into another river. The boundary of the Riverfront Area associated with Hop Brook extends landward 200 feet from the mean annual high water line. Riverfront Area located within the potential project construction areas consists of existing cleared and previously disturbed land associated with Hop Brook Dam.

Floodplain: Floodplains are generally characterized as areas of land which are subject to flooding during a 100-year flood. Floodplains are typically considered to be hazardous to development activities. Usually, naturally vegetated floodplains provide habitat for wildlife, floodflow reduction, sedimentation control, maintain water quality, and aid in the transport and deposition of sediment and nutrients within riverine systems.

The floodplain in Northborough downstream of the Hop Brook Dam is shown in Figure 7 (Appendix C-1). Outside of Northborough, Hop Brook Dam becomes a smaller influence on the floodplain of the Assabet River, which is controlled by multiple other dams in the watershed. Temporary, short-term minor adverse impacts to the floodplain would occur during the installation of the ACBs and scour protection wall within the auxiliary spillway. After construction, the ACBs should not have any permanent adverse impacts on the downstream floodplain.

Air Quality: Air quality is generally defined as how clean or polluted air in a specific area is, and what associated health effects may be of concern. The DEP monitors several air quality criteria pollutants subject to National Ambient Air Quality Standards (NAAQS) including sulfur dioxide (SO_2), ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), lead (Pb), and two categories of particulate matter ($\leq$10 microns [PM_{10}] and $\leq$ 2.5 microns [$PM_{2.5}$]) (DEP 2011).

Northborough falls within the Boston-Lawrence-Worcester 8-hour ozone nonattainment area as defined by the EPA [15]. The Clean Air Act and Amendments of 1990[16] define a "nonattainment area" as a locality where air pollution levels persistently exceed NAAQS, or that contributes to ambient air quality in a nearby area that fails to meet standards. Northborough is a nonattainment area for 8-hour ozone. The area is in attainment for all other criteria pollutants (EPA 2011). Air quality data for the Summer Street sampling location in Worcester (the closest location to the dam) for 2010 is presented in Table I (DEP 2011).

[15] http://www.epa.gov/ozonedesignations/1997standards/areamaps/BostonMA.pdf
[16] 42 U.S.C 7401 *et seq.*

TABLE I: SUMMER STREET AIR QUALITY DATA SUMMARY

Criteria Pollutant	Level[1/]	Standard
Sulfur dioxide (ppm)	0.002	0.03
Ozone (ppm)	0.083	0.075
Carbon monoxide (ppm)	1.55	9
Nitrogen dioxide (ppb)	13.99	53
Particulate Matter (PM_{10}) ($\mu g/m^3$)	15.5	150
Particulate Matter ($PM_{2.5}$) ($\mu g/m^3$)	8.7	15

Note: ppm=parts per million; ppb=parts per billion; $\mu g/m^3$=micrograms per cubic meter
Source: DEP (2011)
[1/]Annual arithmetic mean

Recreation: Although "No Trespassing" signs have been posted, the dam and the impoundment area when not flooded are used informally for hiking and biking.

Hazardous Waste: Prior to the acquisition of the land for development of the Hop Brook Dam, portions of the site (approximately 10.5 acres) were used for automobile salvage operations. In addition, to automobile salvage, illegal dumping resulted in the identification of two "automobile burn areas," a "wire dump area," "a bottle dump area," a "municipal burn area," and an "electrical component" dump area when an initial site investigation was completed in 2001 (Rizzo Associates 2005). Soil and sediment analysis in the disposal areas identified elevated concentrations of metals (lead, antimony, and zinc), polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and petroleum hydrocarbons that were primarily surficial. Groundwater sample analysis revealed lead concentrations above the Massachusetts Contingency Plan GW-1 standard. The wire dump area was remediated in 2001; remediation of the remainder of the site was scheduled in 2006 (Rizzo Associates 2005) but has been delayed due to lack of funding. Although these areas fall within the pool area of the dam, rehabilitation of the dam would not affect any of the areas. Further investigation of these areas for cultural resources are not warranted since they have been previously investigated (Rizzo Associates, 2005) and are located within the pool area of the dam, therefore, they will not be affected by rehabilitation of the dam.

Cultural and Historic Resources: There are no historic properties listed on the National Register of Historic Places (National Register) within the vicinity of the project site (NPS 2008). The closest property listed on the National Register, the General Ward Artemas Homestead, is located approximately 1.7 miles to the west of the site on Main Street in the Town of Shrewsbury. There are properties listed on the National Register located further downstream of the dam. However, these properties are not located within the project area.

The APE for the project is the access road into the site and the project construction area. The APE was previously disturbed for construction of the dam and Dikes. Other than the dam itself, there are no structures within the APE.

The Massachusetts SHPO has concurred with the determination that there are no historic properties in the APE. The SHPO letter concurring that no historic properties will be affected by the rehabilitation of the dam is provided in Appendix E-2.

Land Use: In the 1958 watershed plan, the SuAsCo watershed is described as 10 percent developed and 90 percent, cropland, grassland, forest, and open water. In the 50 years since, the area has developed as a residential area for Boston and Worcester commuters (Town of Northborough 2008). Current land use in the Hop Brook Dam drainage area (based on 2005 data in MassGIS) is summarized in Table J; almost 50 percent of the area is residential, mostly low to medium density. Land in the drainage area is predominantly privately owned (90 percent), with the rest being state- or local government-owned.

Table J also summarizes land use under ultimate build-out, as projected from zoning (Bhatti Group 2005). Residential and commercial/industrial development is projected to increase by about 25 percent in the area and will result in a similar loss of forested land cover and agricultural land. A current land use map of the Hop Brook Dam drainage area is presented as Figure 8 in Appendix C-1.

TABLE J: LAND USE IN THE HOP BROOK DAM DRAINAGE AREA

	Current		**Ultimate Build-out**	
Land Use	**Acres**	**Percent**	**Acres**	**Percent**
Residential	1,538	49	2,134	68
Forest	1,148	36	511	16
Agricultural	153	5	63	2
Commercial, industrial	57	2	257	8
Other (wetlands, open land, water, etc.)	249	8	180	6
Total	*3,145*	*100*	*3,145*	*100*

Source: Bhatti Group 2005 and MassGIS 2009b

Land use in the Hop Brook Dam floodplain is summarized in Table K. Commercial and industrial areas are located south of the dam along the Northborough-Westborough town line and coincide with a development and commercial area along State Route 9 (Turnpike Road), which runs east-west between Northborough and Southborough. A golf course is located along the north bank of Hop Brook, southeast of the dam and prior to the brook's confluence with the Assabet River. Commercial and industrial development is a higher percentage of land use in the floodplain than in the dam drainage area because of the historical growth of towns along the region's rivers. Land in the floodplain is mostly privately owned (78 percent), with smaller proportions of state- or local government-owned (18 percent) and federally owned (4 percent) land. Future land use in the floodplain is not expected to change significantly because of zoning restrictions on floodplain development. Figure 9 (Appendix C-1)

TABLE K: LAND USE IN THE HOP BROOK DAM FLOODPLAIN

Land Use	Acres	Percent
Forest	1,058	32
Residential	312	9
Commercial, industrial	297	9
Agricultural	243	7
Other (wetlands, open land, water, etc.)	1,414	43
Total	*3,324*	*100*

Source: MassGIS 2008b

Socioeconomic: The Town of Northborough, founded in 1766, is approximately 18.8 mi^2 in area, with an estimated population of 14,013 according to the 2010 census (USCB 2011). The population density of Northborough equals approximately 752 persons per square mile of land area. The town primarily serves as a residential community to rural commuters of the metropolitan areas of the Cities of Boston and Worcester although it does contain a burgeoning research and development park as well as several working farms. Table L summarizes the socioeconomic data for the Town of Northborough (the location of the dam) compared to the Commonwealth of Massachusetts, and the United States. The Hop Brook Dam, as a flood control structure, provides an annual flood protection benefit of $236,400 to downstream communities.

Environmental Justice: Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations[17], requires that "each federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations" (CEQ 1997). Environmental Justice neighborhoods are defined as neighborhoods with minority, non-English speaking, and low-income and/or foreign born populations. According to MassGIS data derived from the 2000 U.S. Census[18], Northborough has no environmental justice populations that could be affected by project construction (MassGIS 2008a). As shown in Table L, minority groups constitute 10.6 percent of the population in Northborough, and families in poverty are 1.7 percent of all town families.

The closest Environmental Justice area is a large Environmental Justice Zone located to the southeast of the dam in the Town of Westborough. Figure 10 (Appendix C-1) depicts the Environmental Justice Zone in proximity to the dam. There would be no adverse effects to environmental justice communities downstream of Northborough, because the project has no adverse effects downstream of the dam and only benefits downstream populations. Residents of Environmental Justice neighborhoods in the vicinity of the dam were provided the opportunity to participate in the planning process through a town meeting and a public invitation for public comment. The public planning process for the plan is discussed in greater detail in the Public Participation section.

[17] Executive Order 12898 of February 4, 1994. Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. Federal Register 59:32.
[18] Environmental Justice data for the 2010 U.S. Census is not yet available.

Human Health and Safety: The human health and safety of the dam includes items of risk such as flood, drought, or other disasters affecting the security of life or health; potential loss of life, property, and essential public services due to structural failure; and other environmental effects such as changes in air or water quality. As previously discussed, since the dam does not meet current federal and state dam safety guidelines and standards, there is an increased risk of downstream flooding as a result from dam failure which could greatly impact the lives, health, and essential public services such as infrastructure and emergency assistance. Other factors, such as drought and air quality, would not be affected by a potential dam failure.

TABLE L: SUMMARY OF SOCIOECONOMIC CHARACTERISTICS

	Northborough		Worcester Co.		Massachusetts		United States	
Population and Race	**14,155**		**798,552**		**6,547,629**		**308,745,538**	
White	12,405	87.6%	683,361	85.6%	5,265,239	80.4%	223,553,265	72.4%
Black/African American	142	1.0%	33,314	4.2%	434,398	6.6%	38,929,319	12.6%
Asian	1,158	8.2%	31,815	4.0%	349,768	5.3%	14,674,252	4.8%
Other	435	3.1%	48,086	6.0%	479,374	7.3%	28,656,454	9.3%
Native American	16	0.1%	1,976	0.2%	18,850	0.3%	2,932,248	0.9%
Hispanic or Latino of any race	381	2.7%	75,422	9.4%	627,654	9.6%	50,477,594	16.3%
Age								
Median age	42.5		39.2		39.1		37.2	
Over 18 years of age	10,382	73.3%	611,321	76.6%	5,128,706	78.3%	220,958,853	71.6%
Over 65 years of age	1,829	12.9%	102,035	12.8%	902,724	13.8%	40,267,984	13.0%
Language Spoken At Home								
English only	11,529	81.4%	618,359	77.4%	4,849,884	74.1%	229,673,150	74.4%
"less than very well"	616	4.4%	55,071	6.9%	546,663	8.3%	25,223,045	8.2 %
Spanish	419	3.0%	55,426	6.9%	484,965	7.4%	36,995,602	12.0%
Indo-European	845	6.0%	48,776	6.1%	555,058	8.5%	10,666,771	3.5%
Asian-Pacific	587	4.1%	19,733	2.5%	230,616	3.5%	9,340,583	3.0%
Other languages	50	0.4%	10,401	1.3%	70,396	1.1%	2,539,640	0.8%
Disability Status								
Population five years of age and older	1,348	10.5%	90,524	11.3%	699,252	10.7%	36,354,712	11.8%
Education								
High school graduate or higher	73.1%		61.4%		63.3%		56.7%	
High school including GED	1,586	11.2%	153,461	19.2%	1,168,464	17.8%	52,225,602	16.9%
Associates degree	629	4.4%	47,073	5.9%	337,594	5.2%	15,553,106	5.0%
Bachelor's degree	3,237	22.9%	109,305	13.7%	992,307	15.2%	36,244,474	11.7%
Graduate or professional degree	2,134	15.1%	65,736	8.2%	746,592	11.4%	21,333,568	6.9%
Employment, Class of Worker and Commuter Status								
Labor force pool (population > age 16)	10,612	75.0%	430,491	53.9%	3,595,428	54.9%	156,966,769	50.8%
Employed	7,327	51.8%	381,625	47.8%	3,225,103	49.3%	139,033,928	45.0%
Unemployment	418	3.0%	48,866	6.1%	365,805	5.6%	16,883,085	5.5%
Private for profit workers	6,314	44.6%	227,293	28.5%	2,183,486	33.3%	108,824,975	35.2%
Self-employed workers – includes agriculture, forestry, fishing, hunting	415	2.9%	18,531	2.3%	194,76070	3.0%	8,740,557	2.8%

TABLE L: SUMMARY OF SOCIOECONOMIC CHARACTERISTICS

	Northborough		Worcester Co.		Massachusetts		United States	
Non-profit workers	585	4.1%	34,263	4.3%	405,111	6.2%	15,437,277	5.0%
Government	598	4.2%	48,922	6.1%	419,789	6.4%	20,640,111	6.7%
Federal	100	0.7%	5,037	0.6%	66,420	1.0%	3,550,266	1.1%
State	64	0.5%	17,814	2.2%	118,307	1.8%	6,153,845	2.0%
Local	573	4.0%	26,071	3.3%	235,062	3.6%	9,219,242	3.0%
Occupation								
Management, professional and related occupations	4,095	28.9%	150,744	18.9%	1,402,769	21.4%	49,975,620	16.2%
Service occupations	819	5.8%	66,168	8.3%	559,683	8.5%	25,059,153	8.1%
Sales and office occupations	1,623	11.5%	94,147	11.8%	756,895	11.6%	34,711,455	11.2%
Production, transportation, and material moving occupations	373	2.6%	43,639	5.5%	285,760	4.4%	16,590,396	5.4%
Construction, extraction, and maintenance occupations	417	2.9%	26,927	3.4%	220,046	3.4%	12,697,304	4.1%
Commuting to Work								
Worked in county of residence	3,820	27.0%	268,686	33.6%	2,072,085	31.6%	99,361852	32.2%
Worked outside county of residence	3,500	24.7%	91,150	11.4%	958,412	14.6%	32,364,811	10.5%
Worked outside the state of residence	105	0.7%	13,121	1.6%	121,049	1.8%	5,214,347	1.2%
Housing								
Number of households		5,110		303,080		2,547,075		116,716,292
Number of housing units		5,314		326,788		2,808,254		131,704,730
Occupied	5,110	96.2%	303,080	92.7%	2,547,075	90.7%	116,716,292	88.6%
Owner occupied	4,319	84.5%	200,322	66.1%	1,587,158	62.3%	75,986,074	65.1%
Income								
Median annual household income		$102,969		$61,212		$62,072		$50,046
Median family income		$120,560		$76,485		$78,653		$60,609
Per capita income		$44,833		$29,316		$33,203		$26,059
FT*, year-round male median income		$88,125		$56,337		$56,959		$46,500
FT*, year-round female median income		$48,447		$42,218		$46,213		$36,551
Poverty								
Number of families	425	3.0%	57,496	7.7%	536,906	8.2%	34,888.246	11.3%

Source: 2000 and 2010 U.S. Census Bureau Data *FT = Full-time

STATUS OF OPERATION AND MAINTENANCE

The DCR is responsible for operation and maintenance of the Hop Brook Dam. A site inspection of the dam on April 18, 2008, found that, in general, the dam was in "Satisfactory" condition, with some eroded paths and exposed embankment soils, deterioration of the downstream end of the principal spillway pipe, some irregularity along the top of dam, and minor damage to the embankment due to animals and unauthorized use of the facility. Maintenance of the dam, particularly along Dike A, has occurred to address areas of eroded paths along the slopes and undulations along the top of the dam. During the site inspection, the surveyed elevations showed no sign of settlement or erosion along the structure that would limit the function of the dam. The 2008 site inspection found that the stilling basin below the dam is well maintained. A video pipe inspection determined that there were no areas of concern or movement within the principal spillway outlet pipe. A drain pipe associated with Dike B could not be accessed due to accumulated sediments; the drain pipe associated with Dike C appeared to be in good condition. The corrugated metal pipe culvert beneath Tomblin Hill Road was also found to be in good condition during the inspection (H&S 2009).

SEDIMENTATION

Hop Brook Dam was designed with 22 acre feet of sediment storage capacity for a 50-year period. Sediment accumulation in the pool area has been minimal, and sediment removal has occurred only incidentally to debris removal around the primary spillway. Sediment accumulation is expected to be minimal for the remaining 54-year evaluation period of the dam. Using current NRCS standard procedures, the sediment storage volume required for the first 46 years is estimated to be 11.5 acre-feet. The additional sediment volume over the remaining 54-year period, assuming 20 years to watershed build-out, is estimated to be 8.6 acre-feet. The total estimated volume, 20.1 acre-feet, is less than the original 50-year sediment storage design capacity of 22 acre-feet.

BREACH ANALYSIS AND HAZARD CLASSIFICATION

As defined in Section 520.21(e) of the NRCS Title 210 National Engineering Manual, Hop Brook Dam is classified as a high hazard dam "where failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railroads." The original NRCS hazard classification was also a high hazard structure. Under Commonwealth of Massachusetts Dam Safety Rules and Regulations[19], the dam is classified as a Class I (High) hazard structure and a "Large" size structure because it has a storage capacity greater than 1,000 acre feet.

Failure of the dam at maximum pool will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highways or railroads. Flooding along Hop Brook and the Assabet River from a dam breach is expected to impact approximately 901 residences, 71 non-residential properties, 120 roads, 1 school, 1 fire department, and 1 dam, plus utilities in the floodplain, as discussed in the *Consequences of Dam Failure* section of this report.

[19] 302 CMR 10.00

A comprehensive hydrologic and hydraulic analysis was performed to evaluate the capacity of the Hop Brook Dam under current and build-out conditions (see Appendix D, Investigations and Analysis Report). The analysis included development of several hydrologic and hydraulic models to predict maximum water surface elevations under a series of design storms. Design storms were established based on NRCS design criteria for earthen dams. The primary tool used for the evaluation of the existing capacity and rehabilitation alternatives was the NRCS's beta-test version of the WinDAM B computer model, intended to replace the Site Analysis Integrated Development Environment (SITES) model in the near future. Inflow hydrographs for the model were developed by modeling different rainfall scenarios in a HEC-HMS model and routing the hydrographs in a HEC-RAS unsteady-state model.

Results of the analysis indicate that under current and build-out conditions the dam does not meet the principal spillway capacity criteria because the 10-day drawdown requirement is not met during the passage of the principal spillway hydrograph (PSH). In addition, the analysis indicates that tailwater reduces the effectiveness of the auxiliary spillway to freely pass the FBH without overtopping the dam. The dam is overtopped under existing and potential future watershed build-out conditions by 0.99 feet and 1.12 feet, respectively. Consequently, the dam does not meet the design freeboard criteria since it does not allow for passing of the FBH without overtopping the dam.

Stability (surface erosion potential) and integrity (breaching potential) of the auxiliary spillway were also evaluated by routing the stability design hydrograph (SDH) and FBH, respectively. The results of the analysis indicate that under current and build-out conditions concentrated flows will likely develop during the passage of design storms, ultimately resulting in severe headcut erosion and likely breaching of the auxiliary spillway.

Table M summarizes the hydrologic and hydraulic analyses for the original design and for current and build-out conditions.

TABLE M: HYDROLOGIC AND HYDRAULIC ANALYSES SUMMARY

	Original Design[1/]	**Current Conditions**[2]	**Build-out Conditions**[2]
Comparison elevations			
Riser crest (elevation, feet)	301.3	301.3	301.3
Crest of auxiliary spillway (elevation, feet)	308.3	308.3	308.3
Top of dam low point (elevation, feet)	312.3	312.3	312.3
Bottom width of auxiliary spillway (feet)	340	340	340
PSH (principal spillway hydrograph)			
Max. water elevation (feet)	301.3	306.33	308.17
Drawdown (days)	—	13.87	14.17
Starting pool elevation for SDH and FBH	—	299.64	300.33
SDH (stability design hydrograph)			
Max water elevation (feet)	304.9	309.23	309.25
Meets stability criteria (Y/N)	—	N	N
Meets integrity criteria (Y/N)	—	N	N
FBH (freeboard design hydrograph)			

TABLE M: HYDROLOGIC AND HYDRAULIC ANALYSES SUMMARY

	Original Design[1/]	Current Conditions[2]	Build-out Conditions[2]
Max. water elevation (feet)	312.1	313.29	313.42
Available freeboard (feet)	0.2	-0.99	-1.12

[1/] Source: SuAsCo Watershed Hop Brook (A-3-c) Design Report, July 5, 1962.
[2/] Source: WinDAM Model for Hop Brook Dam developed by AMEC (AMEC 2011b).

The HEC-RAS computer program and its Dam Breach component were used to perform breach analysis of the dam during a PMF flood event. Breach parameters were estimated using empirical formulas developed by Xu and Zhang (2009). The unsteady-flow model was used to route PMF flows through the Hop Brook Dam and predict breach wave progression along Hop Brook and the Assabet River following a hypothetical dam breach. The results of analysis predict that a breach of Hop Brook Dam would occur 5.54 hours from the beginning of the probable maximum precipitation (PMP) event and would result in maximum discharge of 10,015 cubic feet per second (cfs) through the breach opening. The peak flows associated with the PMF breach event are expected to be an order of magnitude greater than the 100-year flood event for Hop Brook and the Assabet. Maximum water surface elevations resulting from the breach wave progression were used to estimate inundation areas downstream of the dam.

Breach inundation maps prepared by AMEC (2011c) are provided in Appendix C-3.

POTENTIAL MODES OF DAM FAILURE

Several potential modes of failure for dams were examined for Hop Brook Dam.

Sedimentation: Excessive sedimentation can reduce flood storage volume and clog spillways, reducing the hydraulic efficiency of the dam. Sedimentation of the Hop Brook Dam over the past 45 years has been minimal, and failure due to sedimentation is not probable.

Hydrologic Capacity: Hydrologic failure of a dam can occur by breaching the auxiliary spillway or overtopping the dam during a storm event. The integrity and stability of the auxiliary spillway and embankment is dependent on depth, velocity, and duration of flow; vegetative cover; and resistance to erosion. As discussed in the previous section, *Breach Analysis and Hazard Classification*, the dam does not meet current dam safety design criteria for a high hazard dam. Therefore, the potential for failure due to a deficiency in hydrologic capacity at the dam is considered high.

Seepage: Embankment and foundation seepage can contribute to failure of an embankment by removing (piping) soil material through the embankment or foundation. As the soil material is removed, voids can be created, allowing ever increasing amounts of water to flow through the embankment or foundation until the dam collapses due to the internal erosion. Seepage that increases with an increase in pool elevation is an indication of a potential problem, as is stained or muddy water. Foundation and embankment drainage systems can alleviate the seepage problem by removing the water without allowing soil to be transported away from the dam.

The downstream slopes of the dikes are protected with rock toe drains to collect seepage. Seepage waters collected by the toe drain of Dikes B and C flow through separate culverts beneath Route 20, through a connecting ditch on the east side of the road, and through a culvert beneath Tomlin Hill Road before joining flows from the principal spillway at Smith Pond. No visible signs of seepage were observed during the inspection conducted in 2008 (H&S Environmental 2009). No sloughing, sinkholes, or other surface anomalies indicative of embankment instability were observed. In the near future, seepage presents a low potential mode of failure for the dam.

Seismic: The integrity and stability of an earthen embankment are dependent on the presence of a stable foundation. Foundation movement through consolidation, compression, or lateral movement can cause the creation of weak zones or voids within an embankment, separation of the principal spillway conduit joints, or in extreme cases, complete collapse of the embankment. Central Massachusetts is not an area of significant seismic risk, and there is low potential for seismic activity to cause the failure of the dam.

Embankment Slope Failure: An embankment slope failure allows increased saturation, weakens the integrity of the dam during large storms, and could result in a catastrophic failure. Slope failure can also create slides and sloughing that lower the top of the dam elevation so that overtopping may occur during large storms.

The Hop Brook Dam shows no visible signs of slope failure, sloughing, or any other noticeable indications of instability on the embankments. The embankments of the dam are grass covered. Recent inspection of the dam noted vehicular ruts degrading the quality of the vegetation but little exposure of embankment soils. Wear, compression, and some damage to grass covering the dam and dikes were observed, but the vegetation was in the process of recovery. Maintenance at the dam includes mowing and control and clearing of woody vegetation along the dam embankments and spillways. A possible slough approximately 7 feet wide that was observed at Dike A during the inspection should continue to be monitored during future inspections. Embankment slope failure presents a low potential mode of failure for Hop Brook dam.

Material Deterioration: Material used in the principal spillway system and fences are common construction materials, but they are subject to weathering and chemical reaction due to natural elements within the soil, water, and atmosphere. As a result of this weathering, concrete components can deteriorate and crack, metal components can rust and corrode, and leaks can develop. Embankment failure can occur from internal erosion caused by these leaks.

Based on the results of the site inspection in 2008 (H&S Environmental 2009), the structure appears to be in good to satisfactory condition with no evidence of deterioration on any of the materials that would require structural repair at this time. The principal spillway outlet pipe appears to be in good condition based on video inspection. Accumulated sediment prevented access of the drain pipe at the toe of Dike B. The pipe associated with Dike C was found to be in good condition. As a result, the potential failure of the existing dam due to deteriorating components is judged to be low. However, the dam should continue to be monitored, especially after significant storm events, because of the age of existing structural components.

CONSEQUENCES OF DAM FAILURE

Historically, pool elevation at the Hop Brook Dam has never reached the level of the auxiliary spillway; however, the dam does not meet the principal spillway capacity criteria (under current or build-out conditions) because the 10-day drawdown requirement is not met during passage of the principal spillway hydrograph (PSH) and more than 15 percent of the maximum volume remains after 10-days. In addition, failure of Hop Brook Dam under more-extreme wet weather conditions is anticipated to impact 901 residential structures and 71 non-residential structures, the majority of which are located in the Towns of Northborough and Hudson. Most of these structures would have already experienced the effects of flooding resulting from the PMP storm prior to the dam breach. Maps depicting the breach inundation zone downstream of the dam are provided in Appendix C-3.

Within the Town of Northborough, dam break flooding is anticipated along Hop Brook and the Assabet River. Under the PMP design storm, flooding is expected to impact approximately 336 residential structures, 10 non-residential structures, and major roadways including Route 135 and Route 20. The Town of Westborough would experience flooding along the Assabet River. The PMF in the Hop Brook Dam drainage area and general wet weather flooding of the Assabet River upstream of Hop Brook in conjunction with the dam failure is anticipated to result in the backwater flooding of the Assabet River just upstream of the confluence of Hop Brook with the Assabet River. Flooding is also expected along the Assabet River downstream of Hop Brook. Approximately 24 residential structures and 26 non-residential structures within the Town of Westborough are anticipated to be impacted and major roadways (including Route 135 and Route 9) would also be impacted.

Within the City of Marlborough, flooding is anticipated along the Assabet River, impacting major roadways (including Interstate-290), nine residential buildings, and six non-residential buildings. Four non-residential structures, 36 residential structures, and several roads along the Assabet River in the Town of Berlin would experience impacts from flooding.

Within the Town of Hudson, the PMF breach wave is anticipated to impact approximately 496 residential buildings and 25 non-residential buildings along the Assabet River, a public school, the Hudson Fire Department, and many roadways are also expected to experience flooding. The hydraulic model ends at the Washington Street Dam, located in the Town of Hudson and, therefore, floodplain for the areas downstream of the dam is not available. However, it is likely that the dam does not have a hydraulic capacity sufficient to pass the dam breach flood wave and is anticipated to be overtopped and fail, impacting additional structures further downstream.

A catastrophic breach of the dam would affect an area larger than the 100-year floodplain, so the damages from a breach would far exceed the damages sustained from a 100-year flood event without the dam in place, and it would also most likely include the loss of lives.

ALTERNATIVES

FORMULATION PROCESS

The NRCS and DCR jointly evaluated a wide range of nonstructural and structural measures for flood protection downstream of Hop Brook Dam. Alternatives were developed that are ineligible for financial assistance under PL 83-566 as amended by PL 106-472 as well as alternatives that are eligible for federal funding. To be eligible for federal assistance, an alternative must meet the requirements of PL 106-472.

The following alternatives were considered:

- Future without Project—the most probable future conditions to be realized if the federally funded NED alternative is not implemented.
- Rehabilitation of the dam (NED Alternative).
- Decommissioning
- Relocation
- Floodproofing
- Other dam rehabilitation alternatives.

The principal spillway outlet structure would not be affected by any of the alternatives. The flood profiles of storms less frequent than the design storms would not be affected by proposed rehabilitation measures and were not included in the alternatives analysis.

Alternatives that would provide no additional benefits but would cost substantially more than the NED Alternative were eliminated from detailed analysis. The Future without Project Alternative was used to evaluate the remaining feasible rehabilitation alternative, which is the NED Alternative.

The alternatives evaluation period was established as 54 years to provide continuing safe service for the original 100-year SuAsCo watershed planning period. The period of analysis is 55 years to allow for 1 year of design and construction. All alternatives were developed to function for a minimum of 54 years with proper maintenance. Engineering plans depicting the alternatives considered are provided in Appendix C.

ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED STUDY

Structural and nonstructural measures that were considered but eliminated from detailed study are described in the following paragraphs:

Decommissioning

Decommissioning would require taking the dam out of service through a full or partial breach of the dam. Decommissioning would eliminate flood storage behind the dam and eliminate the flood protection provided by the dam. Without further mitigation, downstream properties would be subject to increased flooding, increased property damage, and increased risk of loss of life.

There would be construction costs and impacts related to the dam breach, but there would be no long-term dam maintenance and repair costs.

Decommissioning would not meet the sponsors' objective to maintain the downstream flood damage reductions provided by the existing project. To meet this objective, decommissioning would have to be supplemented by other measures such as floodproofing or relocation. The costs of relocation and floodproofing would exceed the structural cost of rehabilitation by more than 400 percent, so the decommissioning alternative was eliminated from detailed study because it was not considered to be a reasonable alternative due to cost.

Relocation

Land downstream of the dam that would be affected by failure of the dam would be purchased and the residences or businesses relocated out of the flood area. The Hop Brook Dam provides approximately 12.5 percent of the flood damage reduction benefits in the SuAsCo watershed. A major property that would be affected if the dam were to fail is Clock Tower Plaza/Place, which is valued at approximately $44 million. The proportioned cost of that property to the Hop Brook Dam is then $5.5 million (12.5 percent of $44 million). When costs for protecting roads and other infrastructure, other property purchases, and relocation are added to this cost, the cost of this nonstructural alternative far exceeds the cost of structural alternatives to rehabilitate.

Floodproofing

To protect areas that would be affected by failure of the dam, individual properties could be floodproofed or floodwalls could be constructed along the river downstream of the dam. A 3,000-foot-long floodwall would be required to protect just the approximately $44 million complex at the Clock Tower Plaza/Place, and the cost of the property needed for the structure would exceed $2.2 million. Several miles of floodwalls would also be required for Routes 20, 9, 135, 290, and 495 and for multiple developed properties along Hop Brook. The cost of these floodwalls is estimated at $6.6 million. This alternative is unreasonable, because the cost is more than 400 percent higher than the cost of the structural alternative considered for final analysis, there are no additional flood-protection benefits, and the environmental impacts of project construction would be greater.

Channel and Overbank Improvements Downstream

Since the results of hydraulic modeling indicate that tailwater submergence conditions limit the effectiveness of auxiliary spillway capacity improvements, channel and overbank improvements downstream of Hop Brook Dam were evaluated through an iterative approach. Using the existing dam configuration, the HEC-RAS model was used to evaluate the effects of channel and overbank improvements on tailwater conditions. The following changes would be required to produce conditions in which tailwater does not overtop the existing auxiliary spillway crest and allows for auxiliary spillway capacity improvements:

1. Removal of Smith Pond Dam and the Otis Street Bridge.
2. "Restoration" of a 500-foot wide trapezoidal channel between the Route 20 culvert and Smith Pond. Smith Pond causes considerable backwater at the Route 20 culvert during the PMP storm and its removal had a positive impact on conveyance. Portions of this dredging and "restoration" extend into the Smith Pond impoundment and increased its storage capacity.
3. Alteration of the cross section immediately upstream of the Route 20 culvert. This change to the model allowed the roadway surface to act as the controlling weir on the upstream side of the Route 20 crossing. In addition, large mounds of earth that caused divided weir flow over the roadway at Route 20 were removed from the model and overbanks were edited to provide increased weir flow over the roadway profile based on an updated survey data. These changes to the model were helpful at reducing tailwater, but they did not provide enough conveyance without more modification.
4. Replacement of the Route 20 culvert with an open-span high clearance bridge that follows the road profile and spans the entire length of the open channel to meet with high ground. In addition, the cross section downstream of Route 20 was re-graded to conform to the road profile and maximize weir flow through the lower elevations, similar to the upstream cross-section.

This alternative was considered to be unfeasible due to the associated extensive impacts to infrastructure and natural resources as well as the anticipated high-cost of construction. In addition, the auxiliary spillway would still have to be upgraded. The removal of Smith Pond Dam and the Otis Street Bridge does not comply with the project sponsors' objectives and goals. Additionally, the removal of Smith Pond Dam would cause considerable permanent impacts to natural resources. Furthermore, the removal of the Route 20 culvert and installation of an open-span high clearance bridge combined with the considerable amount of earthwork needed to complete this alternative would cause permanent impacts to the area. For these reasons, this alternative is not feasible.

Reducing the FBH Design Storm

An incremental analysis of the Inflow Design Flood (IDF) was conducted to determine if the Hop Brook Dam qualifies for a reduction in the FBH storm, which for "High Hazard Dams", is generated by the PMP storm. Per NRCS policy, the use of a storm smaller than the PMP is allowed if the reduction is justified by an incremental analysis of the IDF. The results of the IDF analysis conducted for the Hop Brook Dam showed that the 75% PMP storm qualifies as the selected IDF provided that appropriate controls are put in place to ensure that no further development occurs in the entire PMP breach inundation zone. However, this requirement was strongly objected to by the owner of the dam, the DCR. As a result, this alternative was not further developed and the design criteria set forth by the NRCS in Technical Release (TR) 60 for "High Hazard Dams" (i.e. using the PMP to generate the FBH) were applied when evaluating, developing, and designing rehabilitation measures for the Hop Brook Dam.

Armor the Auxiliary Spillway with an ACB Blanket

Early versions of the alternative plans (i.e., raising the elevation of the dam embankment dam with a geocell wall) included the proposed installation of an ACB blanket that extended from the auxiliary spillway downstream into the adjacent wetlands area. The ACB blanket was approximately 52,700 ft^2 (1.21 acres) and would have resulted in approximately 17,842 ft^2 (0.41 acres) of permanent wetland impacts. The ACB blanket would have also significantly increased the total cost of construction for the geocell wall and geocell wall alternatives. Given the greater cost and permanent wetland impacts associated with this alternative, the ACB blanket was removed from further consideration and is not considered a viable alternative for rehabilitation.

Rehabilitation (NED Alternative): Increase Height of Dam with a Parapet Wall, Armor the Auxiliary Spillway, and Install a Scour Protection Wall

The height of the dam and Dikes A, B, and C could be increased to an elevation of 313.6 feet NAVD88 to meet the federal freeboard design criteria. This would provide additional protection against overtopping during the PMP event while maintain the existing configuration of the auxiliary spillway. The main dam and Dike A could be raised by means of a parapet wall (concrete or vinyl sheet-pile), which would span the entire length of the main dam and Dike A, transitioning into the raised embankment of Dike B. West of the abutment of the dam, the parapet wall would tie into natural high ground. Abutment walls would be constructed along both sides of the auxiliary spillway to ensure closure of any possible gaps during the high water event. In addition, the increase in reservoir level would create additional loads in the embankment fill structure and on adjacent outlet structures. Increase in storage capacity may change pore pressures and seepage patterns in the embankment and foundation. Consequently, a rock toe drain and relief wells located at the downstream slope of the embankment would require evaluation to assess the ability of these features to accommodate increased hydraulic loading. In addition to raising Dike C to elevation 313.6 feet NAVD88, the dike would also have to be extended to tie in natural high ground.

The auxiliary spillway would be armored using ACBs to provide erosion protection to underlying natural soils or structural embankments from the forces and stresses of flow. They may be used when vegetation cover is unstable under the conditions of the design event. ACB systems are composed of a mattress of interconnected concrete block units that are typically connected by geometric interlock, cables, or ropes. Geotextile fabric is provided beneath the ACB mattress to provide a separation from sub-grade soil, preventing migration of sediment particles through the voids in the block. The construction of an ACB system involves removal of existing vegetation and topsoil up to 8-inches below the existing grade. Construction activities include the installation of geotextile and drain fill prior followed by the installation of the concrete blocks that are backfilled and compacted using the proper material. The spillway would be armored a distance of 76 ft from the centerline of the dam to El. 294.8 ft (NAVD88), which is the approximate toe of the existing spillway.

In addition to armoring the auxiliary spillway with ACBs, a 12-inch thick scour protection wall would be installed at the downstream end of the ACB armoring to prevent erosion and undermining of the spillway and the main dam during flood events. The scour protection wall

would extend 15 ft below grade to El. 279.8 ft (NAVD88). Construction of the scour protection wall would require excavation, dewatering of the excavation, and construction of a cast-in-place reinforced concrete wall.

The cost of raising the earthen embankment of the dam by using a parapet wall and armoring the auxiliary spillway would be approximately $2,070,400, which is comparable to Alternative 2 (described below). However, this alternative was considered unfeasible after reviewing its impacts on aesthetics, maintenance and access, and recreational uses for the dam. As such, this alternative was removed from consideration. The Engineering Plans depicting this alternative are provided in Appendix C-2.

DESCRIPTION OF ALTERNATIVE PLANS

The following alternatives were developed in detail and are evaluated in this Watershed Plan/EA.

Alternative 1 - Future without Project (No Federal Action Alternative)

The Future without Project Alternative (No Federal Action Alternative) depicts the most probable future conditions to be realized in absence of any of the alternative plans studied. The DCR, the owner of the dam, and the agency under which the Commonwealth's dam regulations are implemented, has determined that it would rehabilitate the dam to meet current federal dam safety standards without federal funds. The DCR may use other alternative rehabilitation methods identified in the SuAsCo Watershed Hop Brook Floodwater Retarding Dam Phase II Report (H&S Environmental 2009) or develop its own plan to bring the dam into compliance with federal standards, but for the purposes of comparing this alternative to the NED Alternative, it is assumed that the DCR would implement the same plan as described in Alternative 2. This assumption was made because the recommended plan is the most cost-effective and least environmentally damaging of all plans considered.

Alternative 2 – Raise the Dam using a Geocell Wall, Armor the Auxiliary Spillway, and Install a Scour Protection Wall

Under Alternative 2, the existing earthen embankment and Dikes A, B, and C would be raised to elevation 313.6 feet NAVD88 to provide additional protection against overtopping during the PMP event. Raising the earthen embankment and Dike A would be accomplished by using layers of geocell panels filled with infill material. Raised Dike A would transition into the embankment of Dike B, which would be raised using compacted earth fill. Dike C would be also raised by compacted earthen fill; however, the dike would have to be extended to tie into natural high ground. Due to the limited onsite survey data, the exact length of Dike C to allow for natural high ground tie-in will need to be verified (based on the available LiDAR data the approximate length of Dike C extension is 500 feet). Once additional survey data is compiled, the exact point at which the Dike will tie into natural high ground will be determined. However, the Dike extension will not extend into private land and will be completely located on land which is already on land owned by the DCR.

The geocells are typically three-dimensional honeycombed cellular structures that form a confinement system when infilled with compacted soil or other appropriate material. The cellular confinement reduces the lateral movement of soil particles, thereby maintaining compaction and forms a stiffened mattress or slab that distributes loads over a wider area. The result is high bearing capacity, reduction of structural layer thickness, and longer term durability. The geocell wall consists of a geotextile layer, foundation layer, geocell wall panels, and compacted backfill. To maintain the existing crest width, the foundation layer will be cut into the embankment and the additional wall will be built up at a 1H:3V slope. Four layers of 6-inch geocell wall panels will increase the height of dam to the required elevation. A combination of native silty sand material with topsoil is recommended as infill for the outer geocells and gravel for the inner cells and foundation layer. Compacted general fill with two layers of geosynthetic fiber for additional reinforcement would be used in between the upstream and downstream wall. Proprietary anchors and keys would interconnect panels of geocells and anchor them in the existing embankment, preventing sliding and uplifting of panels.

In addition to raising the existing earthen embankment, the auxiliary spillway would be armored using ACBs to provide erosion protection to underlying natural soils or structural embankments from the forces and stresses of flow. ACB systems are composed of a mattress of interconnected concrete block units, which are typically connected by geometric interlock, cables, or ropes. Construction of an ACB type system requires the removal of the vegetation and organic topsoil layers (up to 8 inches), excavation to the subgrade elevation to enable installation of the bedding layer, installation of the drainage layer, placement of the ACBs which are typically fashioned into mats, and placement of infill materials. The drainage layer, which is an integral part of the system typically, consists of a geotextile designed to filter the embankment soils, and a crushed stone drainage media. Grading and placement of this layer is critical so as to enable the proper placement of the ACBs in intimate contact with the drainage layer. Should flow occur between the drainage layer and the ACB units, laboratory testing has shown that the blocks can lift and degrade the system. Due to its specific design, the system conforms to changes in the subgrade while maintain the protective cover. The system can also be designed to allow for vegetation to be re-established and improve the visual appearance.

The limited disturbance required for installation, low frequency of use leading to reduced maintenance costs, overall cost savings, and the ability to cover the ACBs with a layer of sacrificial loam and seed to maintain the natural appearance of the area are significant benefits to using ACBs in this location. The spillway would be armored a distance of 76 ft from the centerline of the dam to El. 294.8 ft (NAVD88), which is the approximate toe of the existing spillway.

Additionally, a 12-inch scour protection wall would be installed at the downstream end of the ACB armoring and extend for approximately 150 feet along the toe of the main dam to prevent erosion and undermining of the spillway during flood events. The scour protection wall would extend 15 ft below grade to El. 279.8 ft (NAVD88). Construction of the scour protection wall would require excavation, dewatering of the excavation, and construction of a cast-in-place reinforced concrete wall.

The recommended plan is to raise the existing earthen embankment and Dike A using a geocell wall, armor the existing auxiliary spillway using an ACB system, install a scour protection wall in the downstream exit channel of the auxiliary spillway, raise Dikes B and C with earthen material, and extend Dike C as shown on in the construction drawings in Appendix C. The total cost of the rehabilitation cost is $2,054,400.

Rehabilitating the dam to meet current federal and state dam safety and performance guidelines and standards will greatly reduce the risk of dam failure due overtopping. Other potential modes of failure (e.g. sedimentation, seepage, seismic, and embankment slope failure) were discussed in the "Potential Modes of Dam Failure" and are considered to be low or minimal. Engineering Plans depicting this alternative are provided in Appendix C-2.

COMPARISON OF ALTERNATIVES

Table N summarizes and compares the two alternative plans. Refer to the NRCS-CPA-52 form provided in Appendix E-3 for additional information on the effects of each alternative.

TABLE N: SUMMARY AND COMPARISON OF CANDIDATE PLANS

Effects	Alternative 1 Without Project	Alternative 2 (NED)
Measures	Raise earthen embankment to elevation 313.6 feet NAVD88; armor auxiliary spillway with ACBs and and scour protection wall.	Raise earthen embankment to elevation 313.6 feet NAVD88; armor auxiliary spillway with ACBs and and scour protection wall.
Project investment	$2,054,400	$2,054,400
National Economic Development Account[1/]		
Beneficial, annual	—	$97,800
Adverse, annual	—	$97,800
Net beneficial	—	$0
Environmental Quality Account		
Air Quality	Minimal, temporary impact due to construction activity.	Minimal, temporary impact due to construction activity.
Fish and wildlife	Minimal, temporary impact from construction.	Minimal, temporary impact from construction.
Forest resources	Minimal, minor permanent impacts from clearing land for the extension of Dike C, minor temporary impact. Minimal clearing for construction access. Disturbed areas will be restored following construction.	Minimal, Minimal, minor permanent impacts from clearing land for the extension of Dike C, minor temporary impact. Minimal clearing for construction access. Disturbed areas will be restored following construction.
Invasive species	Minimal impact. The site contains limited areas of invasive species. Disturbed areas will be restored with native vegetation. Best Management Practices (BMPs) will be utilized during construction to reduce the risk of spreading invasive species to or from the site.	Minimal impact. The site contains limited areas of invasive species. Disturbed areas will be restored with native vegetation. BMPs will be utilized during construction to reduce the risk of spreading invasive species to or from the site.
Land use	No impact. The land use of the area will not change as a result of the dam rehabilitation.	No impact. The land use of the area will not change as a result of the dam rehabilitation.
Migratory birds	Minimal, temporary impact due to construction activity.	Minimal, temporary impact due to construction activity.
Natural resources	Minimal, temporary effect from construction. Vegetated areas will	Minimal, temporary effect from construction. Vegetated areas will

TABLE N: SUMMARY AND COMPARISON OF CANDIDATE PLANS

Effects	Alternative 1 Without Project	Alternative 2 (NED)
	be restored.	be restored.
Prime and unique farmland soils	No effect.	No effect.
Riparian areas	Minimal temporary impact from construction.	Minimal temporary impact from construction.
Scenic beauty	No impact. The viewshed is not impacted by the project.	No impact. The viewshed is not impacted by the project.
Sedimentation and erosion	Minimal, temporary impact from construction. BMPs will be implemented during construction activities. Positive, long-term impact by reducing floodflow velocities as a result of the dam rehabilitation.	Minimal, temporary impact from construction. BMPs will be implemented during construction activities. Positive, long-term impact by reducing floodflow velocities as a result of the dam rehabilitation.
Threatened and endangered species	No impact to federally protected habit or federally protected species. No impact to nesting/hibernation habitat for wood turtle, state species of special concern	No impact to federally protected habit or federally protected species. No impact to nesting/hibernation habitat for wood turtle, state species of special concern
Water quality	Minimal, temporary impacts from construction.	Minimal, temporary impacts from construction.
Water resources	Minimal, temporary impacts from construction.	Minimal, temporary impacts from construction.
Wetlands	Potential for <1 acre of temporary and permanent disturbance during construction; wetlands will be avoided to the maximum extent possible. Wetland areas will be restored if not avoided.	Potential for <1 acre of temporary and permanent disturbance during construction; wetlands will be avoided to the maximum extent possible. Wetland areas will be restored if not avoided.
Regional Economic Development Account		
Other Social Effects Account		
Dam safety	Reduced threat of dam failure	Reduced threat of dam failure
Public health and safety	Reduced threat to life from dam failure	Reduced threat to life from dam failure
Flood damages	Reduced threat of flood damages from dam failure	Reduced threat of flood damages from dam failure

[1/] Per sections 1.7.2(a)(4)(ii) and 2.1.1(b)(2) of the "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" (P&G), U.S. Water Resources Council, March, 1983, allowing for abbreviated procedures, damage reduction benefits have not been estimated because they are the same for both alternatives, and no net change in benefits occurs when comparing the two candidate plans to each other. The federally assisted alternative (Alternative 2) is displayed within a zero-based accounting context that credits local costs avoided (Adverse, annual) as adverse beneficial costs (Beneficial, annual) consistent with P&G 1.7.2(b)(3). Net benefits are zero because the total project cost is equal to the claimed benefits and the resulting B/C ratio is 1.0:1.0.

ENVIRONMENTAL CONSEQUENCES

The following is a description of the effects that each alternative will have on the natural and human environment. Resources or concerns that are not affected by either alternative (e.g., climate, geology) are not included. For each resource topic presented, the existing conditions are summarized to provide a better understanding of the effects. Because the dam would be rehabilitated under both alternatives (by the DCR with no federal funding under Alternative 1 and by the sponsors with partial federal funding under Alternative 2), the effects of the alternatives are the same for all resource categories. The NRCS-CPA-52 form (provided in Appendix E-3) documents the environmental effects of both actions.

DAM SAFETY

- **Present Conditions:** The dam does not meet current safety and performance standards and guidelines for a dam in this location and there is a risk of the dam failing from overtopping during the PMP. The pool elevation would overtop the dam by 1.4 to 1.6 feet in current and build-out conditions, respectively, for the freeboard storm. Modeling results indicate that the auxiliary spillway does not meet all necessary design criteria for current and ultimate build-out conditions, and discharge velocity would create erosive forces on the spillway slope. The risk of failure is low, but the consequences of failure would be catastrophic.

- **Alternative 1—Future without Project (Rehabilitation by DCR):** The existing earthen embankment and Dikes A, B, and C would be raised to elevation 313.6 feet NAVD88 to provide additional protection against overtopping. The auxiliary spillway would be armored to prevent erosion of the spillway if storm flows pass down the spillway and a scour protection wall will be installed in the downstream exit channel. The rehabilitation would bring the dam into compliance with federal and state criteria, and the threat of the dam failing during the PMP would be reduced.

- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

HIGHLY ERODIBLE LAND

- **Present Conditions:** Less than 10 percent of the Hop Brook Dam drainage area and less than 5 percent of the downstream floodplain are highly erodible lands.

- **Alternative 1—Future without Project (Rehabilitation by DCR):** Rehabilitation of the dam would occur in the area of the embankment of the auxiliary spillway and Dikes A, B, and C. Rehabilitation would result in these areas being able to withstand high flow events and would protect these areas from the threat of erosion and potential failure. As such, any potential impact to highly erodible lands could be considered positive as these areas, which under natural conditions would erode under high flow events, will be protected from erosion and degradation. Therefore, rehabilitation of the dam will not result in any adverse impacts to highly erodible land.

- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

HUMAN HEALTH AND SAFETY

- **Present Conditions:** The dam is structurally safe; however, there is a threat of failure from overtopping of the dam or erosion of the auxiliary spillway during the PMP. There is a significant threat from dam failure to human life and safety for residents, motorists, and other people using downstream facilities.

- **Alternative 1—Future without Project (Rehabilitation by DCR):** The threat of loss of life or unsafe conditions from the dam failing would be reduced through rehabilitation designed to bring the dam into compliance with safety criteria. Flood protection would continue for residents, motorists, and other persons using downstream facilities.

- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

FLOOD DAMAGES

- **Present Conditions:** Failure of the dam also poses a significant threat of damages to private property, roads, and utilities in the breach inundation area.

- **Alternative 1—Future without Project (Rehabilitation by DCR):** The threat of property damage from the dam failing would be reduced through rehabilitation designed to bring the dam into compliance with safety criteria. Flood protection would continue for private property, roads, and utilities in the breach inundation area.

- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

WATER QUALITY

- **Present Conditions:** Water quality in Hop Brook is generally good, with some occurrences of low dissolved oxygen. Hop Brook Dam has little influence on water quality because it does not permanently impound water.

- **Alternative 1—Future without Project (Rehabilitation by DCR):** The proposed rehabilitation of Hop Brook Dam would have minor, temporary impacts on water quality during construction. Turbidity in Hop Brook would be minimized by using BMPs for sediment and erosion control. DCR or its contractor would be required to obtain an NPDES general permit for construction, which would require preparation of an erosion and sediment control plan and installation of BMPs to minimize sediment discharge to the brook.

- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

WETLANDS

- **Present Conditions:** Wetland resources identified at the Site include BVWs, Banks, LUWB, and Riverfront Area. These wetland resources are associated with, or adjacent to, Hop Brook.

- **Alternative 1—Future Without Project (Rehabilitation by DCR):** The auxiliary spillway would be armored with ACBs to prevent spillway erosion and a scour protection wall would be installed at the downstream end of the ACB armoring. Bordering vegetated wetlands would be excavated to install the ACBs and scour protection wall and then restored with native wetland vegetation over the buried spillway armor. In addition, permanent impacts within the 100-foot Buffer Zone associated with the BVW would occur where the geocell wall is proposed to be installed to raise the elevation of the dam and associated dikes. The proposed permanent impacts within the 100-foot Buffer Zone are minimized to the extent feasible; however are necessary to continue to prevent flood damages by complying with current performance and safety standards. It is predicted less than one acre of permanent wetland impacts would occur. Temporary wetland impacts may occur at the toe of the slope of the dam as a result of construction access to embed the proposed armoring system. It is estimated that temporary wetland impacts would be less than one acre. All temporary wetland impact areas would be restored following construction. All other construction staging and access would occur entirely within existing cleared or previously disturbed upland areas. All disturbed areas would be revegetated and restored after construction is complete. State-regulated wetland resources delineated at Hop Brook are not located in the area where construction associated with the rehabilitation would occur, except at the toe of the slope where embedding of the proposed scour protection wall would be located. Portions of the 100-ft Buffer Zone associated with BVW and Riverfront Area associated with Hop Brook are located within potential work areas; however, these areas are comprised of existing cleared or previously disturbed portions of the site. Best management practices would be used during construction to reduce erosion and sediment movement into the downstream wetlands during construction.

- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

FLOODPLAINS

- **Present Conditions:** The 100-year floodplain directly downstream of the dam is limited to the banks of the Hop Brook stream channel.

- **Alternative 1—Future without Project (Rehabilitation by DCR)**: Temporary, short-term minor adverse impacts to the floodplain would occur during the installation of the ACBs and scour protection wall within the auxiliary spillway. After construction, the ACBs should not have any permanent adverse impacts on the downstream floodplain.

- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

FISH AND WILDLIFE HABITAT

- **Present Conditions:** Hop Brook Dam has little effect on fish and wildlife because it does not have a permanent impoundment. The preserved area for the floodwater pool upstream of the dam provides wildlife habitat in addition to the area on the downstream side of the dam where construction would occur.

- **Alternative 1—Future without Project (Rehabilitation by DCR)**: No permanent impacts are anticipated. Less than 1 acre will be disturbed during construction outside the existing maintained dam footprint. Turbidity in Hop Brook and the Assabet River would be minimized through the use of BMPs for sediment and erosion control. Impacts would be minor and temporary.

- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

THREATENED AND ENDANGERED SPECIES

- **Present Conditions:** There are no federally protected species in the area potentially affected by project construction, but habitat for a state species of special concern, the wood turtle, lies along Hop Brook upstream and downstream of the dam.

- **Alternative 1—Future Without Project (Rehabilitation by DCR):** Construction would not affect wood turtle nesting or winter hibernation habitat, which would lie adjacent to or in Hop Brook itself. Construction would not affect the riparian forests or wetlands along the stream where the turtle could forage during the rest of the year. Because the construction area lies within areas designated as turtle habitat, DCR will consult with NHESP as the final design is developed.

- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

AIR QUALITY

- **Present Conditions:** The project area falls within the Boston-Lawrence-Worcester area as defined by the EPA, which is a nonattainment area for 8-hour ozone (EPA 2009).

- **Alternative 1—Future without Project (Rehabilitation by DCR):** No permanent impacts are anticipated. Minor, temporary impacts are expected due to emissions from construction equipment.

- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

RECREATION

- **Present Conditions:** Although "No Trespassing" signs have been posted, the dam and the impoundment area when not flooded are used informally for hiking and biking.

- **Alternative 1—Future without Project (Rehabilitation by DCR)**: No permanent impacts are expected. Minor, temporary impacts to recreation would occur during construction because there would be reduced access to the area for hiking and biking.

- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

HAZARDOUS WASTE

- **Present Conditions:** Several areas of hazardous waste were identified on the site prior to the development of the Hop Brook Dam. Soil sampling identified elevated levels of metals, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and petroleum hydrocarbons. A wire dump area was remediated in 2001. Remediation of the remainder of the contaminated sites was scheduled for 2006, but has since been delayed due to a lack of funding.

- **Alternative 1—Future without Project (Rehabilitation by DCR)**: The contaminated areas fall within the pool area of the dam; however, rehabilitation of the dam would not affect any of the areas.

- **Alternative 2—NED Rehabilitation Plan**: Same as Alternative 1.

CULTURAL AND HISTORIC RESOURCES

- **Present Conditions:** Section 106 coordination with SHPO indicated that there are no cultural or historic resources in the vicinity of the dam.

- **Alternative 1—Future without Project (Rehabilitation by DCR):** SHPO has concurred with the determination that rehabilitation will not result in any adverse impacts to historic resources.

- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

LAND USE

- **Present Conditions:** Current land use in the Hop Brook Dam drainage area is dominated by residential, mostly low to medium density. Land use in the Hop Brook Dam floodplain contains a higher percentage of commercial and industrial land use than in the drainage area because of the historical growth of towns along the region's rivers.

- **Alternative 1—Future without Project (Rehabilitation by DCR):** Rehabilitation of the dam will likely not negatively affect the land use of the area. The area of the dam, including the upstream impoundment and downstream areas owned by DCR will remain as open space. However, the extension of Dike C to tie-into higher ground may require the acquirement of land that is privately owned and is currently residential, but it is unlikely. The DCR plans to make certain that the acquirement of new land is not required for the extension of the Dike.

- **Alternative 2—NED Rehabilitation Plan**: Same as Alternative 1.

CUMULATIVE IMPACTS

Construction of the Hop Brook Dam in 1964 had minor, long-term, direct effects on the environment through the excavation and filling of the structure. Rehabilitation of the dam under either alternative would occur within the area disturbed for construction of the existing structure and, therefore would have no cumulative impact on the environment other than the minor, temporary, construction-related impacts described above.

Since construction, the dam has indirectly affected the natural environment by temporary inundation of the floodplain upstream of the dam during rain events and by trapping sediment that would otherwise move downstream during rain events. The dam has also altered the hydrology of Hop Brook and the Assabet River by reducing downstream flows during storm events, and consequently protecting property and people in otherwise flood-prone areas. Rehabilitation of the dam under either alternative would not change the hydrology of Hop Brook or the Assabet River except for protecting the downstream area from catastrophic flooding that could occur if the dam were to fail. There would be no long-term, cumulative effects from the rehabilitation project.

Future actions in the watershed not related to this project include continued changes to upstream and downstream land use as a result of residential, industrial, and commercial development. Rehabilitation of the Hop Brook Dam would not affect future development, but it would allow the dam to safely pass storm flows under build-out conditions.

CONTROVERSY

There are no known areas of controversy.

RISK AND UNCERTAINTY

The areas of risk and uncertainty associated with this project lie in the accuracy of predicting flood flows and flood elevations, estimating costs associated with each alternative, estimating property values and damage costs and benefits. The uncertainty of flood flows and water surface elevations has the potential for increased damages as development of residential and commercial property alters land use. It is possible that these uncertainties could lead to increased risk to human life in the event of a dam breach regardless of rehabilitation or no federal action. Hydrologic methods and computer modeling used in this analysis are consistent with the standards of practice at this time. The potential impacts for each alternative are estimated using techniques that relate potential damage to lost opportunity. However, these methods are in part based on professional judgment, and actual experiences could be different.

Uncertainties with the analysis of environmental impacts lie with the identification of wetland areas and wood turtle habitat and the risk of invasive species colonizing areas of revegetation. Trained wetland specialists identified wetland areas using standard, well-accepted protocols.

The sponsors will be responsible for verifying wetlands and consulting with DEP as required before construction. Native species will be used for planting to minimize introduction of invasive species, but introduction could occur from adjacent areas. Dike C is proposed to be extended in order to tie-into a higher elevation. Currently, it is unknown as to where this tie-in will occur. However, the tie-in will occur on land currently in DCR ownership. As such, land that is currently not under DCR ownership will not be affected by the proposed dike extension.

Within the context of this study, all alternatives were considered on a comparable basis. There does not appear to be any area that would have resulted in a different decision by using different procedures or conducting more intensive studies.

CONSULTATION, COORDINATION, AND PUBLIC PARTICIPATION

PROJECT SPONSORS

Local sponsoring organizations of the SuAsCo Watershed Plan and Supplement No. 6 are Worcester County Conservation District, Middlesex Conservation District, DCR, and DFW.

PLANNING TEAM

An interdisciplinary planning team provided for the administration of this project through the NRCS nine-step planning process according to the procedures in the NRCS National Planning Procedures Handbook. Some of the tasks undertaken by the planning team include preliminary investigations, hydrologic and engineering analysis, economic analysis, formulation and evaluation of alternatives, and preparation of the Supplemental Plan/Environmental Assessment. The planning team included representatives of the NRCS Massachusetts state office, the NRCS National Water Management Center, DCR, and technical consultants under contract to NRCS.

PUBLIC PARTICIPATION

Public meetings were held in the Town of Northborough on November 20, 2008, and in the Town of Berlin on May 24, 2011, to explain the Watershed Rehabilitation Program, obtain public input on the project, and scope resource problems, issues, and concerns of local residents associated with the Hop Brook Dam project area. The meeting was widely advertised to reach all residents in all demographic groups in the watershed. NRCS distributed a press release that resulted in an article about the meeting in the Worcester Telegram & Gazette on November 12, 2008, and a notice that ran on the Northborough cable TV community access channel for two weeks before the meeting. Also, NRCS distributed a press release on May 6, 2011, that resulted in an article about the meeting in the MetroWest Daily News on May 25, 2011.

Potential alternative solutions to bring the Hop Brook Dam into compliance with current dam safety criteria were presented at the public meeting. A fact sheet summarizing the planned rehabilitation projects at six dams in the SuAsCo watershed was distributed at the meeting. Two members of the public attended the November 10th meeting and four members of the public attended the May 24th meeting; no verbal or written comments were received at the meeting or in the intervening time to the publishing of this Plan.

AGENCY CONSULTATION

Consultation under the Endangered Species Act was completed in August 2011 with a letter from FWS indicating that no federally listed threatened or endangered species or critical habitat are present in the project area (refer to Appendix E-2). It was determined from MassGIS that habitat for a state-protected species lies in the Hop Brook floodplain. Consultation with Massachusetts NHESP indicated that a state-listed species of special concern, the wood turtle, has been found in the area (refer to Appendix E-2). Ultimately, DCR is responsible for completing the consultation and obtaining any permits that may be required.

Consultations with the Massachusetts SHPO and the THPO of the Wampanoag Tribe of Gay Head (Aquinnah) were conducted to determine the presence of any cultural or historic resources within the proposed project area. The SHPO concurred with the NRCS determination that no historic properties would be affected by the proposed project (refer to Appendix E-2). A response has not been received from the THPO.

A site visit was held with the USACE and EPA to discuss the project and permit requirements.

Additional agency coordination will be required during the construction permitting process.

PROVISIONS OF THE PREFERRED ALTERNATIVE

PREFERRED ALTERNATIVE

Alternative 2 – Rehabilitation of the Hop Brook Dam is the preferred alternative. The auxiliary spillway would be modified to meet current safety standards for a high hazard dam and maintain the service life and flood prevention purpose of the dam for the original 100-year planning period. The rehabilitation will consist of (1) raising the existing earthen embankment and three dikes A, B, and C to elevation 313.6 NAVD88 feet and (2) armoring the auxiliary spillway and installing a scour protection wall in the downstream exit channel to safely pass the SDH and FBH discharge flows, and (3) extension of Dike C to tie into natural high ground. Estimated construction cost is $2,054,400.

The risk of dam failure due to overtopping will be reduced by increasing the height of the dam. Although other potential modes of dam failure (e.g. sedimentation, seepage, seismic, and embankment slope failure) are considered to be low or minimal, a failure of the dam would endanger any development in the breach inundation zone. Based on existing land-use and development within the breach inundation zone, 901 residences, 71 non-residential properties, 120 roads, 1 school, 1 fire department, and 1 dam, plus utilities in the floodplain downstream would be affected (Refer to the Breach Inundation Maps in Appendix C).

Table O compares structural data from the original as-built structure, the existing structure, and the planned rehabilitation.

RATIONALE FOR ALTERNATIVE PREFERENCE

Alternative plans were formulated as required by NRCS policy, "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" (P&G) (U.S. Water Resources Council 1983), and the National Environmental Policy Act[20]. According to P&G, an alternative that reasonably maximizes net national economic development benefits is to be formulated. This alternative is to be identified as the NED Plan. Alternative 2 is the NED Plan.

TABLE O: COMPARISON OF STRUCTURAL DATA

Hop Brook Floodwater Retarding Dam	Unit	As Built	Existing Conditions	Planned
Surface area (principal spillway crest)	acres	13	13	13
Surface area (auxiliary spillway crest)	acres	146	146	146
Elevation, top of dam (effective)	feet	313.0	313.0	313.6
Length of dam and Dikes	feet	2,705	2,705	3,105[1/]
Principal spillway	type	standard drop inlet	standard drop inlet	standard drop inlet
Elevation, principal spillway crest	feet	302.0	302.0	302.0
Pipe diameter, principal spillway	inches	36	36	36

[20] 42 U.S.C. 4321 *et seq.*

TABLE O: COMPARISON OF STRUCTURAL DATA

Hop Brook Floodwater Retarding Dam	Unit	As Built	Existing Conditions	Planned
Auxiliary spillway	type	grass-lined channel	grass-lined channel	armored with ACBs with sacrificial grass cover and a scour protection wall
Elevation, auxiliary spillway	feet	308.3	308.3	308.3
Bottom width, auxiliary spillway	feet	340	340	340
Storage, permanent pool	acre-feet	0	0	0
Storage, auxiliary spillway crest	acre-feet	1,340	1,340	1,340
Storage, maximum pool	acre-feet	1,928	1,928	1,928

[1/] The length Dike C will be extended is undetermined. Once more detailed survey data is acquired, the length Dike C will need to be extended will be determined. Subsequent drafts of this plan will reflect the new survey information.

Alternative plans were formulated in consideration of the purposes of the project and concerns expressed during the public scoping process. Formulation of the alternative plans gave consideration to four criteria: completeness, effectiveness, efficiency, and acceptability. Alternatives 1 and 2 are the same project, with the only difference being the use of federal funds for a portion of project costs, and both alternatives meet all four of these criteria. Both alternatives maintain the present level of flood control benefits and comply with current performance and safety standards. Both alternatives produce the same monetary benefits, but the net average annual equivalent benefits between the Future with Federal Project (NED Alternative) and the Future without Federal Project (No Federal Action Alternative) is $0.

PERMITS, COMPLIANCE, AND REQUIREMENTS PRIOR TO CONSTRUCTION

Potential Permits Needed

The specific permitting needs will be determined during the final design of the dam rehabilitation. The DCR is responsible for obtaining all permits. Federal and state permitting and consultation requirements that are likely to be required are summarized in Table P.

TABLE P: SUMMARY OF FEDERAL AND STATE PERMIT AND CONSULTATION REQUIREMENTS

Permit/Consultation	Regulatory Authority	Status
NPDES General Permit for Construction	EPA	(Not yet acquired)
Section 404 CWA General Permit	USACE	(Not yet acquired)
Section 7 Endangered Species Act consultation	USFWS	Completed
Section 106 NHPA consultation	SHPO/THPO	Completed/In progress
MEPA review	EOEA	(not yet initiated)
Chapter 91 Waterways License	DEP	(Not yet acquired)
Chapter 253 Permit to Construct or Alter a Dam	DCR	(Not yet acquired)
Massachusetts WPA Order of Conditions	DEP	(Not yet acquired)
Section 401 Water Quality Certificate	ConComm/DEP	(Not yet acquired)
Massachusetts Endangered Species Act consultation	NHESP	Completed

Compliance with Local, State, and Federal Laws

The sponsors will comply with all applicable local, state, and federal laws in the installation of this project. Under the conditions of the NPDES general permit for construction, the sponsors or their contractor will prepare a stormwater pollution and prevention plan, including an erosion and sediment control plan. In the event that cultural resources are discovered during project installation, construction will be halted in that area, and the resources will be evaluated in accordance with NRCS General Manual 420 part 401.

Mitigation

It is expected that most construction activities would be confined to the existing disturbed and cleared areas previously disturbed as a result of dam construction. Less than one acre of permanent wetland impacts would occur with the armoring of the auxiliary spillway with ACBs and the installation of the scour protection wall. Impacted areas would be restored with native wetland vegetation over the buried spillway armor. Less than 1 acre of temporary wetland impacts may occur during the installation of the armoring system at the toe of the slope of the dam. Final design of the project will avoid the wetlands near the toe of the dam embankments to the extent possible. If wetlands cannot be avoided entirely, impacts would be minimized, and areas disturbed during construction would be re-graded to pre-construction contours and planted with native wetland species. Approximately 1 acre of upland vegetation removal may also be required for storage/stockpile areas or for access along the toe of the dam embankments. The

sponsors would be responsible for preparing an approved sediment and erosion control plan to minimize erosion of disturbed soils and sediment runoff into the pool and Assabet River. The sponsors would also be responsible for ensuring that the sediment and erosion control plan is implemented and maintained during construction and that the site is stabilized after construction. After construction, all temporarily disturbed areas will be re-graded to pre-construction contours and reseeded with native species as per NRCS Critical Area Seeding Standard 342.

As previously discussed, disturbed areas will be revegetated with a native seedmix. In order to reduce the potential to spread invasive species during construction, BMPs will be utilized which will include vehicle washdown areas to prevent invasive stock from being transported to or from the site. Additionally, any fill material will be devoid of any invasive plant material.

Operation, Maintenance, and Replacement

The project will be operated and maintained by the owner. A new Operation and Maintenance (O&M) Agreement will be developed by both the DCR and NRCS for the remaining 54-year program life of the structure and signed by both parties after the final construction drawings and specifications are prepared. O&M activities include but are not limited to inspection, maintenance, and repair of the principal spillway, dam, vegetation, and the auxiliary spillway. Based on data from DCR, it is estimated that O&M activities and replacement costs will total about $6,000 per year.

The new O&M Agreement will be based on the National Operation and Maintenance Manual. Although the sponsors' responsibility to the Federal Government for O&M ends when the O&M agreement expires upon completion of the evaluated life of measures covered by the agreement, the sponsors acknowledge that continued liabilities and responsibilities associated with works of improvement may exist beyond the evaluated life.

Project Agreement

The DCR and NRCS will enter into a Project Agreement in accordance with the NRCS National Contract Grants and Agreement Manual before any work is initiated by either the owner or the NRCS.

Emergency Action Plan

The DCR has prepared an Emergency Action Plan (EAP) for the Hop Brook Dam for the case where the dam is compromised and/or likely to fail (GZA 2008). The EAP identifies areas at risk and dam conditions that would initiate emergency notification procedures. It outlines appropriate actions in the event of a potential failure of the dam and designates the parties responsible for those actions. The owner will review and update the EAP annually, in consultation with local emergency response officials. NRCS, if requested, may provide technical assistance in updating the EAP.

The EAP shall meet the minimum content specified in Part 500.52 of the NRCS Title 180, National Operation and Maintenance Manual (NOMM), Part 500, Subpart F, Section 500.52, and

meet applicable State agency dam safety requirements. The NRCS State Conservationist will determine that a current EAP is prepared prior to the execution of fund obligating documents for construction of the structure.

COST, INSTALLATION, AND FINANCING

The construction associated with the project will be financed jointly by DCR and NRCS. The NRCS will use funds appropriated for this purpose. The eligible project costs including construction, engineering, and project administration to be paid by DCR and NRCS are as follows:

	NRCS	DCR	Estimated Project Cost
Rehabilitation of Hop Brook Floodwater Retarding Dam	$1,340,258	$714,142	$2,054,400

NRCS cost share shall be 65 percent of the total eligible project cost, not to exceed 100 percent of the actual construction costs. An amount up to the percentage rate specified may be satisfied by DCR through the cost of engineering and construction. Real property acquisition could also be used as a portion of DCR's cost-share, but is not expected to be required for this project. The decision on specific DCR-funded components will be negotiated between DCR and NRCS and will be included in the Project Agreement executed before implementation. Construction and engineering costs are eligible for project cost sharing; however, permits are not eligible for cost sharing.

NRCS is responsible for the engineering services and project administration costs it incurs. These costs are not used in the calculation of the federal cost share, but they are included in the Estimated Construction Cost (Table Q). Also, costs of federal, state, and local permits are the responsibility of DCR and are not counted toward the local cost share. See Table R below for a complete description of the total rehabilitation costs.

The furnishing of financial and other assistance by NRCS is contingent on the continuing availability of appropriations by Congress from which payment may be made and shall not obligate NRCS if Congress fails to so appropriate.

ECONOMIC AND STRUCTURAL TABLES

TABLE 1: ESTIMATED INSTALLATION COST

SuAsCo Watershed, Massachusetts

(Dollars)[1/]

Installation Cost Item	Estimated Cost[2/]		
	PL 83-566[21] Funds	Other Funds	Total
Structural measures to rehabilitate Hop Brook Floodwater Retarding Dam	$1,340,258	$714,142	$2,054,400
Total Project	**$1,360,753**	**$709,647**	**$2,070,400**

[1/] Price base: 2012 March 2012

[2/] "PL 86-533 Funds" include NRCS Engineering and Project Administration ($230,823), and "Other Funds" include sponsors' Engineering (permitting) and land rights ($114,385), neither of which are included when calculating eligible federal cost share. Therefore, federal cost share is based on Total Eligible Project Cost of $1,709,192.

[21] As amended by PL 106-472, November 9, 2000

TABLE 2: ESTIMATED COST DISTRIBUTION – WATER RESOURCE PROJECT MEASURES

SuAsCo Watershed, Massachusetts

(Dollars) [1/]

	Installation Cost – PL 83-566 Funds [2/]					Installation Cost – Other Funds					Total Installation Cost
	Construction	Engineering	Project Administration	Land Rights	Total PL 83-566	Construction	Permitting	Project Administration	Land Rights	Total Other	
Structural measures: Hop Brook Floodwater Retarding Dam	$1,109,435	$205,565	$25,258	$0	$1,340,258	$586,156	$110,685	$13,601	$3,700	$714,142	$2,054,400
Nonstructural measures	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Grand total	**$1,109,435**	**$205,565**	**$25,258**	**$0**	**$1,340,258**	**$586,156**	**$110,685**	**$13,601**	**$3,700**	**$714,142**	**$2,054,400**

[1/] Price base: 2012 March 2012

[2/] Federal Engineering and Project Administration costs and sponsors' engineering (permitting) and land rights costs ($345,208) are not included when calculating eligible federal cost share. Therefore, federal cost share is based on Total Eligible Project Cost of $1,709,192.

TABLE 3: STRUCTURAL DATA – DAMS WITH PLANNED STORAGE CAPACITY
SuAsCo Watershed, Massachusetts

Item	Unit	Hop Brook Dam
Class of structure		C
Seismic zone		2
Total drainage area	mi^2	4.91
Runoff curve number (1-day) (AMC II)		75 existing development 82 ultimate build-out
Time of concentration (T_c)	hr	3.97
Elevation top dam	ft	313.6
Elevation crest auxiliary spillway	ft	308.3
Elevation crest principal spillway	ft	301.3
Elevation sediment pool	ft	295.3
Auxiliary spillway type		armored with articulated concrete blocks covered by sacrificial soil/grass layer and a scour protection wall in the downstream exit channel.
Auxiliary spillway bottom width	ft	340.0
Auxiliary spillway exit slope		5H:1V
Maximum height of dam	ft	23
Volume of fill (rehabilitation)	yd^3	6,800[1/]
Total capacity (auxiliary spillway crest)	ac-ft	1,340
Sediment pool aerated	ac-ft	22
Floodwater retarding	ac-ft	1,318
Surface area		
Sediment pool	acre	13
Floodwater retarding pool	acre	146
Principal spillway		
Rainfall volume (1-day)	in	7.36[2/]
Rainfall volume (10-day)	in	13.08[2/]
Runoff volume (1-day)	in	5.25[3/]
Runoff volume (10-day)	in	8.75[3/]
Capacity	ft^3/s	228
Diameter of conduit	in	36
Type of conduit		standard drop inlet; reinforced concrete
Frequency of operation—aux. spillway[4/]	% chance	less than 1
Auxiliary spillway hydrograph[5/]		
Rainfall volume	in	10.61
Storm duration	hr	6

TABLE 3: STRUCTURAL DATA – DAMS WITH PLANNED STORAGE CAPACITY

SuAsCo Watershed, Massachusetts

Item	Unit	Hop Brook Dam
Max. reservoir water surface elevation	ft	310.4
Freeboard hydrograph[6/]		
Rainfall volume	in	25
Storm duration	hr	6
Max. reservoir water surface elevation	ft	313.54
Capacity equivalents		
Sediment volume	in	0.1
Floodwater retarding volume	in	5.1

September 2011

[1/]Original volume of fill during the 1964 construction was 83,500 cubic yards. Net fill: 4,400 yd^3.
[2/]The rainfall volume is based on the Northeast Regional Climate Center data.
[3/]Runoff volume was calculated by SITES.
[4/]Frequency of use is based on the 100-year 24-hour duration, Type II distribution storm event from the Northeast Regional Climate Center's Extreme Precipitation in New York and New England.
[5/]SDH is based on the 6-hr storm.
[6/]FBH is based on the most critical condition from the 6-hr and 24-hr storms.

TABLE 4: ESTIMATED AVERAGE ANNUAL NED COSTS

SuAsCo Watershed, Massachusetts
(Dollars)[1/]

Evaluation Unit	Project Outlays		Total
	Amortization of Installation Cost [2/]	Operation and Maintenance Cost	
Hop Brook Floodwater Retarding Dam	$91,800	$6,000	$97,800
Grand Total	**$91,800**	**$6,000**	**$97,800**

[1/] Price base 2012 March 2012
[2/] Amortized over 54 years at 4.00%

TABLE 5: ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

SuAsCo Watershed, Massachusetts

(Dollars)[1/]

Item	Estimated Average Annual Damage		Damage Reduction Benefit[3/]
	Without Project[2/]	With Project[2/]	
Floodwater			
Crop and Pasture	$0	$0	$0
Other Agricultural	$0	$0	$0
Nonagricultural (Road and Bridge)	$2,300	$2,300	$0
Nonagricultural (Urban)	$236,400	$236,400	$0
Subtotal	$236,400	$236,400	$0
Sediment			
Overbank Deposition	$0	$0	$0
Erosion			
Floodplain Scour	$0	$0	$0
Grand Total	**$236,400**	**$236,400**	**$0**

[1/] Price Base: 2012 March 2012

[2/] Original downstream damages updated using the Consumer Price Index for Nonagricultural (Roads and Bridges) and average tax receipt increases for Nonagricultural (Urban).

[3/] Damage reduction benefits resulting from the recommended plan equal zero as compared to the No Federal Action (future without project) Alternative because they are the same in scope, cost, and effects, and therefore yield equivalent benefits. Positive benefits will accrue as a result of this project as compared to existing conditions, but no attempt was made to compute an estimate of the difference between the future with project and existing conditions because the existing conditions are not the most likely future conditions. The added details would not alter the recommended alternative and, therefore, would not justify the added planning costs. Sections 1.7.2(a)(4)(ii) and 2.1.1(b)(2) of the P&G allow for the abbreviated procedures.

TABLE 6: COMPARISON OF NED BENEFITS AND COSTS

Hop Brook Floodwater Retarding Dam
SuAsCo Watershed, Massachusetts
(Dollars)[1/]

Evaluation Unit	Benefits			Average Annual Cost[3/]	Benefit/Cost Ratio
	Average Annual Benefits		Average Annual Benefits		
	Agriculture-related[2/]	Nonagriculture[3/]			
Hop Brook Floodwater Retarding Dam	$0	$93,000	$93,000	$93,000	1.0:1.0
Total	**$0**	**$93,000**	**$93,000**	**$93,000**	**1.0:1.0**

[1/] Price Base: 2012 March 2012

[2/] From Table 5

[3/] From Table 4. The costs and the benefits for the future with project plan are the same as those for the future without project plan. To maintain consistency with the display in Table 4, the costs associated with the No Federal Action Alternative (Future Without Project) are tracked as a benefit of the preferred alternative. Per sections 1.7.2(a)(4)(ii) and 2.1.1(b)(2) of the P&G allowing for abbreviated procedures, damage reduction benefits have not been estimated because they are the same for both alternatives, and no net change in benefits occurs when comparing the two candidate plans to each other. The federally assisted alternative is displayed within a zero-based accounting context that credits local costs avoided as "other" benefits consistent with P&G 1.7.2(b)(3). Net benefits are zero because the total project cost is equal to the claimed benefits and the resulting B/C ratio is 1.0:1.0.

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INDEX

APPENDIX A

COMMENTS AND RESPONSES

There were no written or verbal comments received during the public comment period for rehabilitation of the dam.

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APPENDIX B

PROJECT MAP

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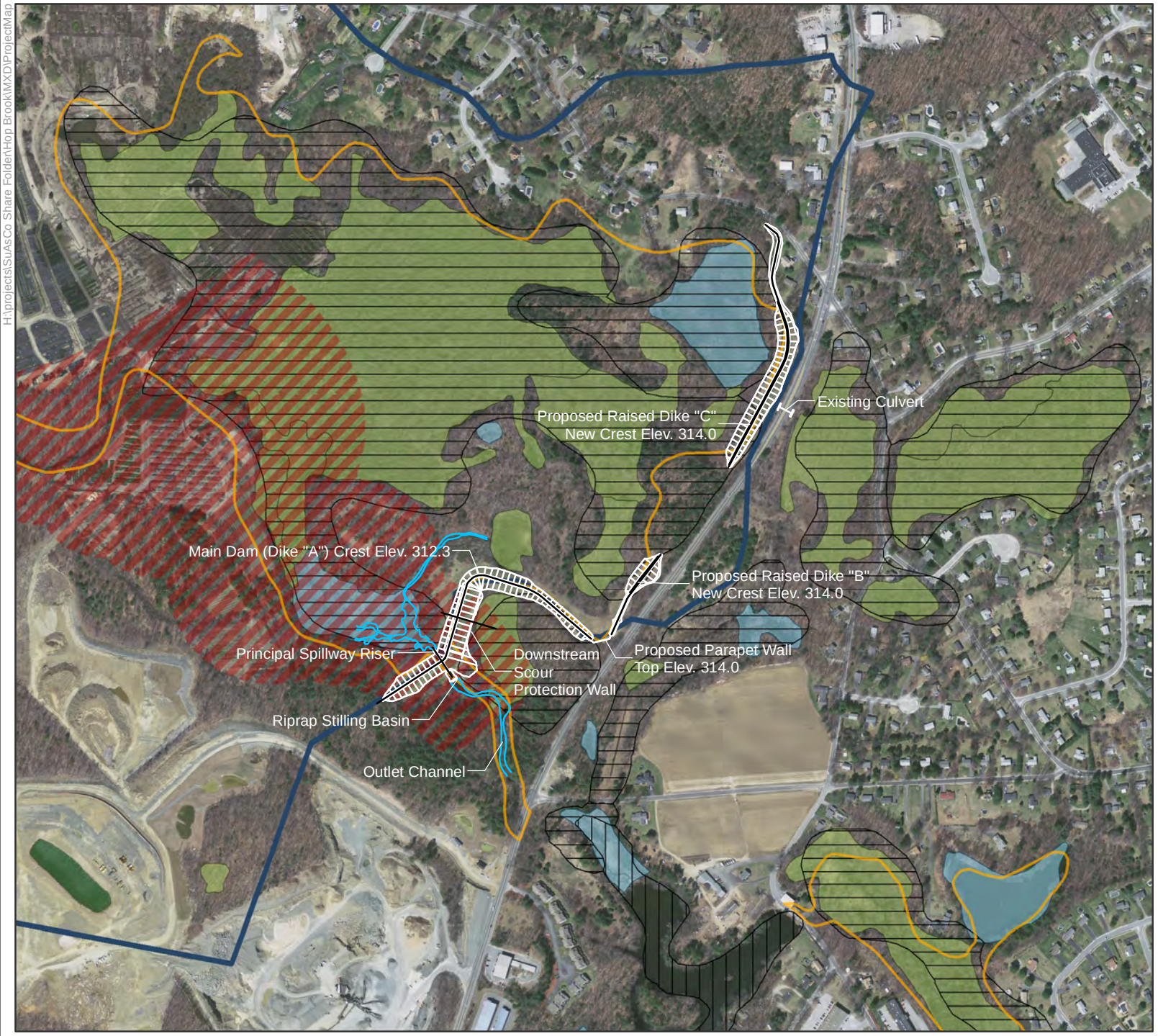


SuAsCo: Hop Brook Dam

Project Map

Legend

- Stream
- 100yr Floodplain
- Hop Brook Dam Watershed
- NHESP Estimated Habitats of Rare Wildlife
- Project Area

NWI Wetlands

- Freshwater Forested/Shrub Wetland
- Freshwater Pond

DEP Wetlands

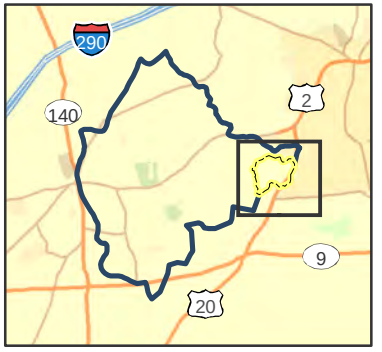
- Marsh/Bog
- Wooded marsh

N

0 200 400 800

Feet

NRCS Natural Resources Conservation Service



Sources: AMEC, 2011; esri, 2006; USFWS, 2010; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, U.S. Geological Survey (USGS), National Geospatial-Intelligence Agency (NGA) and Fugro Earthdata, Inc., 2009

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APPENDIX C

SUPPORT MAPS

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Sub-appendix C-1:

Report maps

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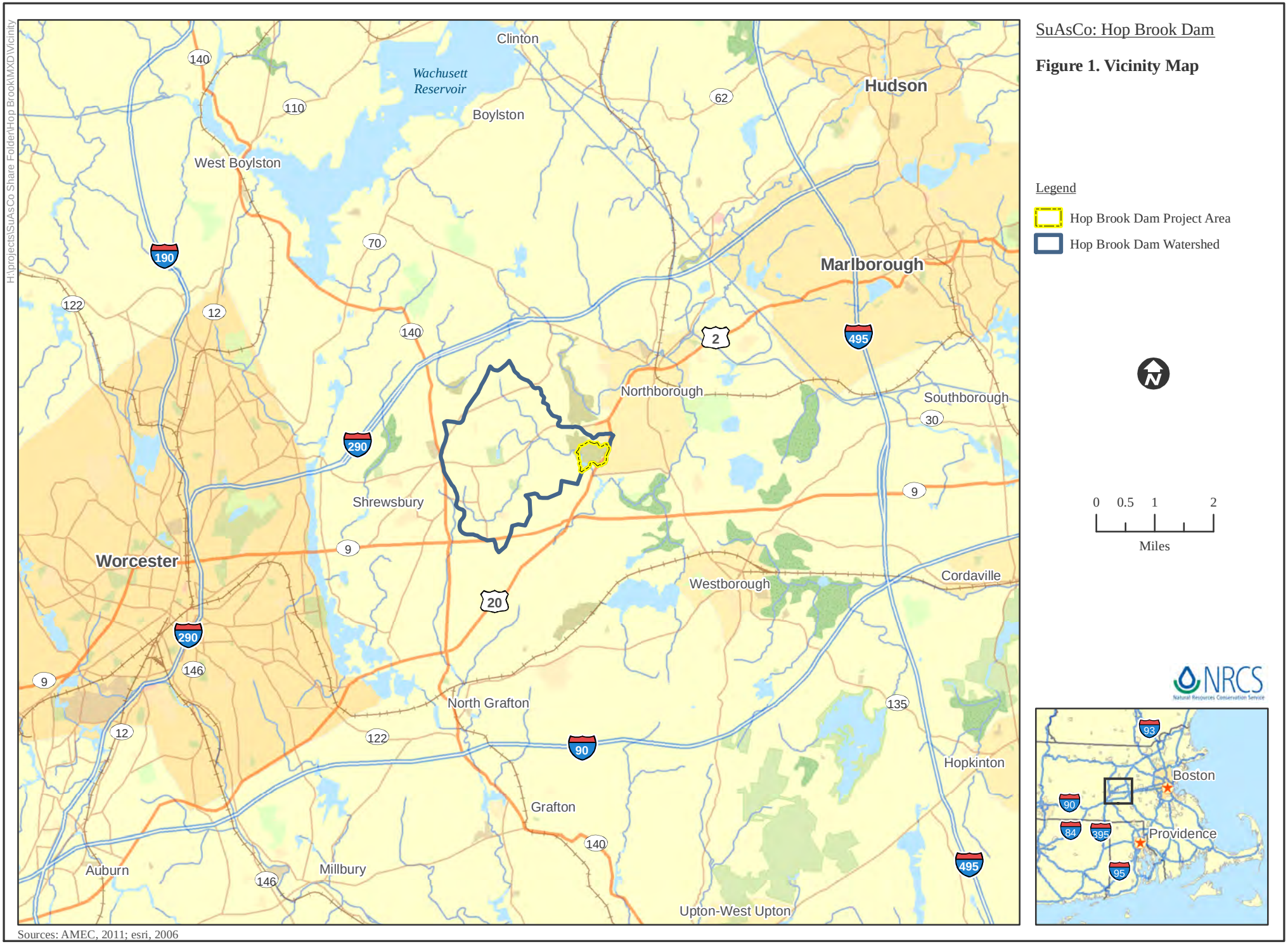

SuAsCo: Hop Brook Dam

Figure 1. Vicinity Map

Legend

- Hop Brook Dam Project Area
- Hop Brook Dam Watershed

0 0.5 1 2

Miles

Sources: AMEC, 2011; esri, 2006

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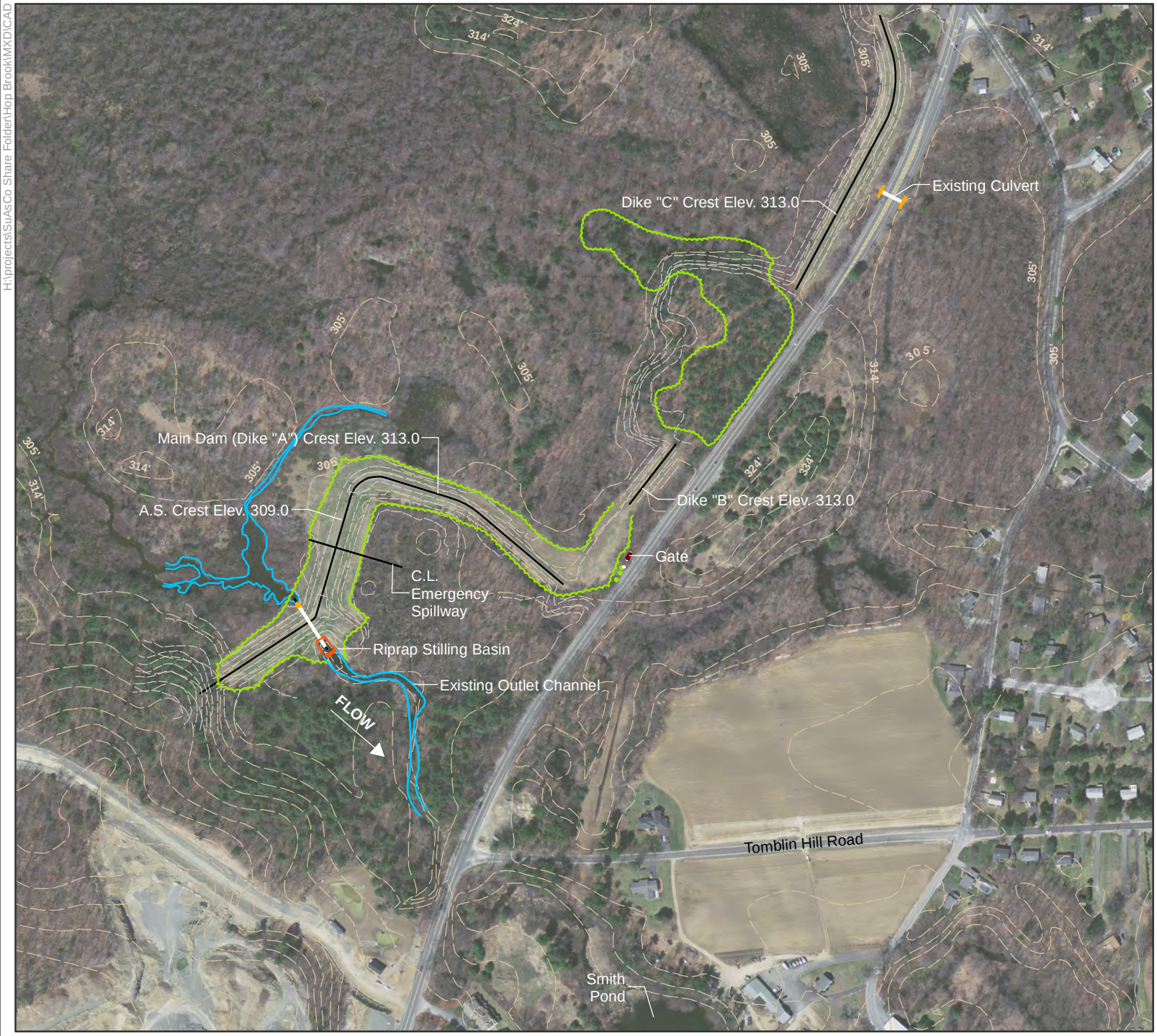
H:\projects\SuAsCo Share Folder\Hop Brook\MXD\CAD

SuAsCo: Hop Brook Dam

Figure 2. Existing Conditions



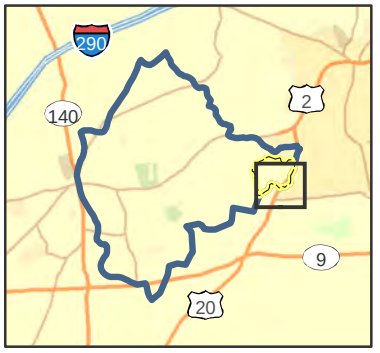
Legend

- Contour Line (Elevation in feet)
- Crest Centerline
- Edge of Forested Area
- Stream
- Hop Brook Dam Project Area
- Hop Brook Dam Watershed

0 100 200 400

Feet

NRCS Natural Resources Conservation Service



Sources: AMEC, 2011; esri, 2006; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, U.S. Geological Survey (USGS), National Geospatial-Intelligence Agency (NGA) and Fugro Earthdata, Inc., 2009

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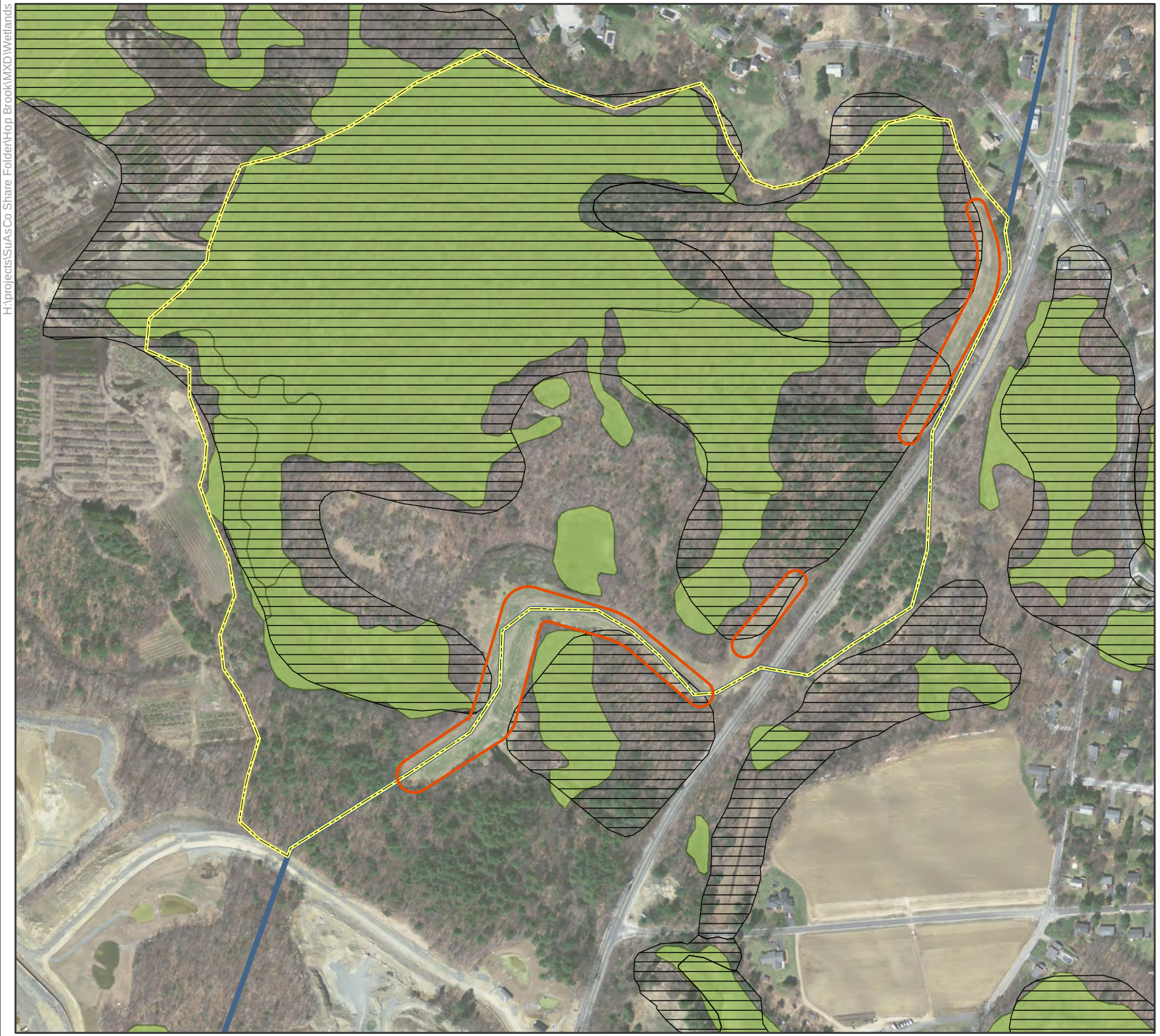
H:\projects\SuAsCo Share Folder\Hop Brook\MXD\Wetlands

SuAsCo: Hop Brook Dam

Figure 3. DEP and NWI Wetlands



Legend

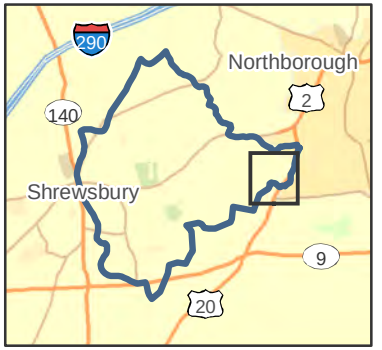
- Hop Brook Dam and Dike Areas
- Hop Brook Dam Project Area
- Hop Brook Dam Watershed
- DEP Wetlands
- NWI Wetlands

N

0 200 400 800

Feet

NRCS Natural Resources Conservation Service



Sources: AMEC, 2011; esri, 2006; USFWS, 2010; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, U.S. Geological Survey (USGS), National Geospatial-Intelligence Agency (NGA) and Fugro Earthdata, Inc., 2009

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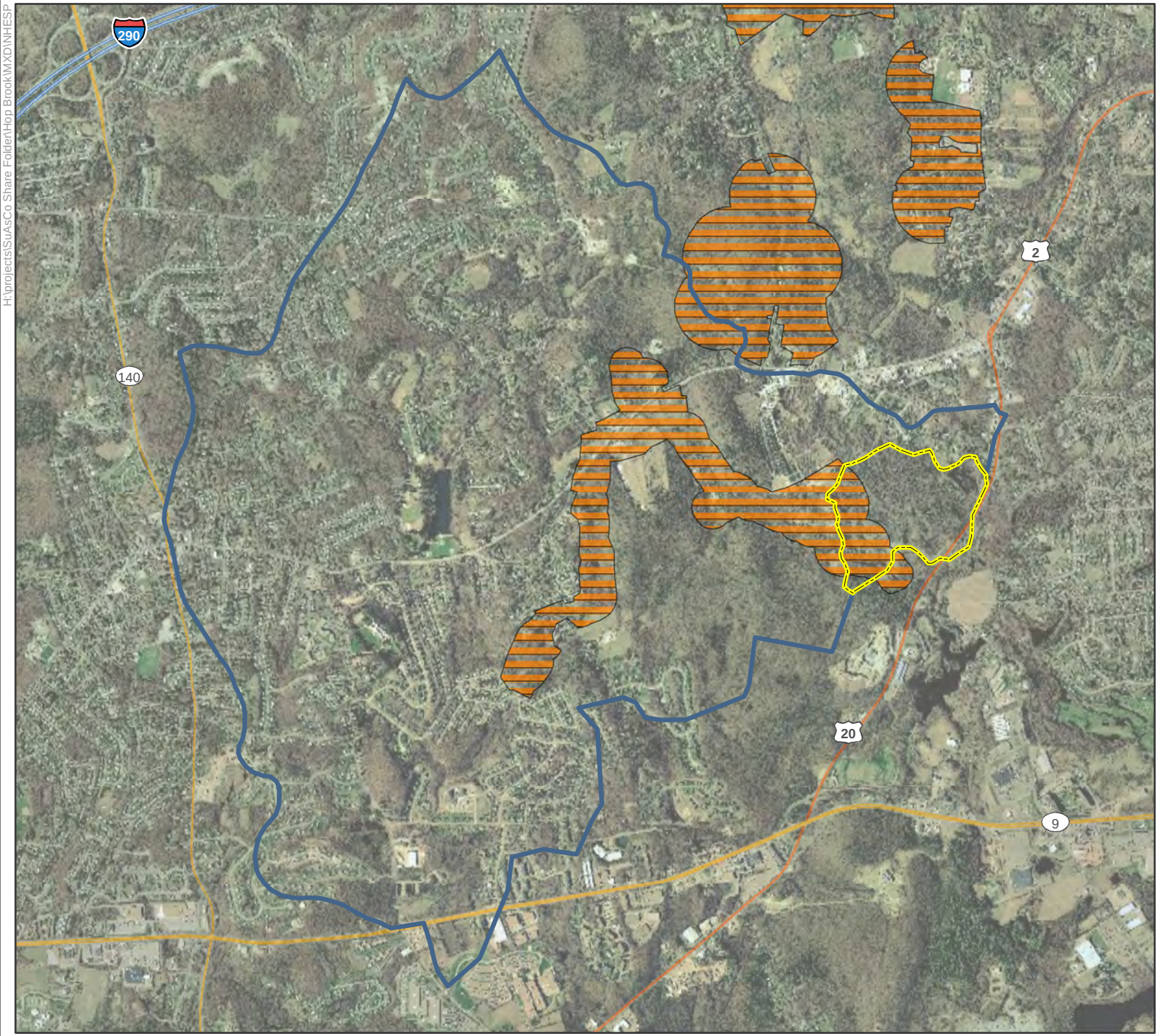
H:\projects\SuAsCo Share Folder\Hop Brook\MXD\NHESP

SuAsCo: Hop Brook Dam

Figure 4. NHESP Estimated Habitats of Rare Wildlife



Legend

- Hop Brook Dam Project Area
- Hop Brook Dam Watershed
- NHESP Estimated Habitats of Rare Wildlife

0 1,000 2,000 4,000

Feet

NRCS Natural Resources Conservation Service

Sources: AMEC, 2011; esri, 2006; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, 2008-09; U.S. Census Bureau, 2010

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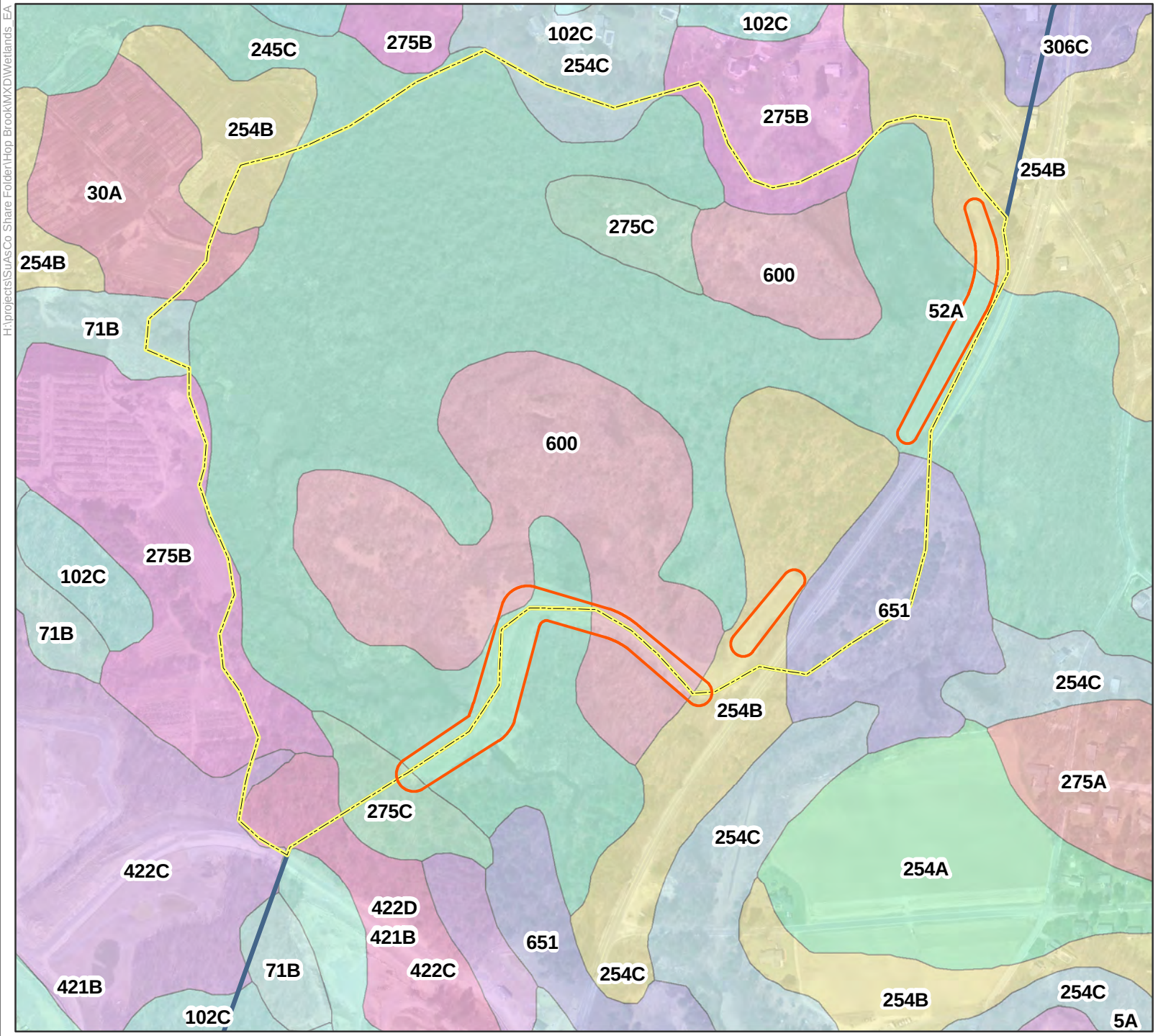


SuAsCo: Hop Brook Dam

Figure 5. Soils Map

Legend

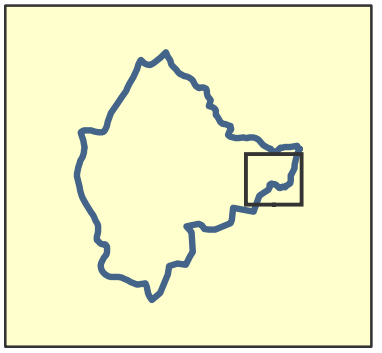
- Hop Brook Dam and Dike Areas
- Hop Brook Dam Project Area
- Hop Brook Dam Watershed

N

0 200 400 800

Feet

NRCS Natural Resources Conservation Service



Sources: AMEC, 2011; esri, 2006; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, U.S. Geological Survey (USGS), National Geospatial-Intelligence Agency (NGA) and Fugro Earthdata, Inc., 2009

H:\projects\SuAsCo Share Folder\Hop Brook\MXD\Wetlands_EA

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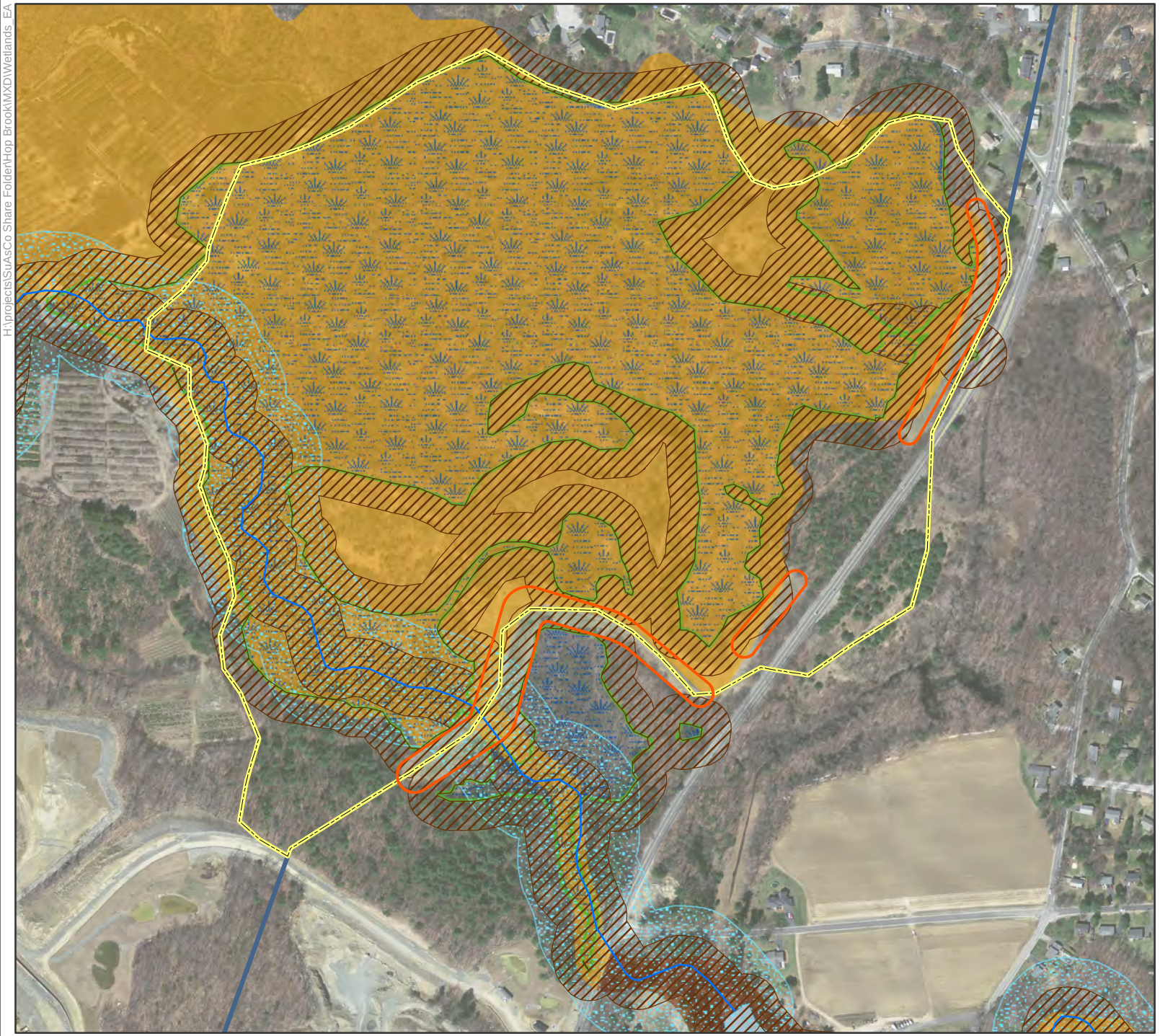
SuAsCo: Hop Brook Dam

Figure 6. Field-Assessed Wetlands



Legend

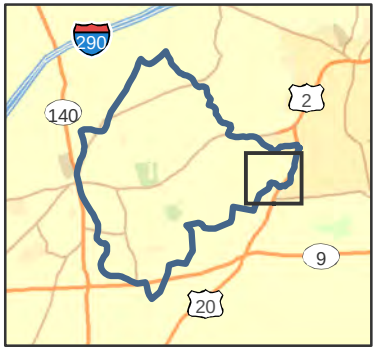
- 100yr Floodplain
- 500yr Floodplain
- Banks
- Buffer Zone
- Field-Assessed Wetlands
- Hop Brook Dam and Dike Areas
- Hop Brook Dam Project Area
- Hop Brook Dam Watershed
- Riverfront Area

N

0 200 400 800

Feet

NRCS Natural Resources Conservation Service



Sources: AMEC, 2011; esri, 2006; FEMA, 1997; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, U.S. Geological Survey (USGS), National Geospatial-Intelligence Agency (NGA) and Fugro Earthdata, Inc., 2009

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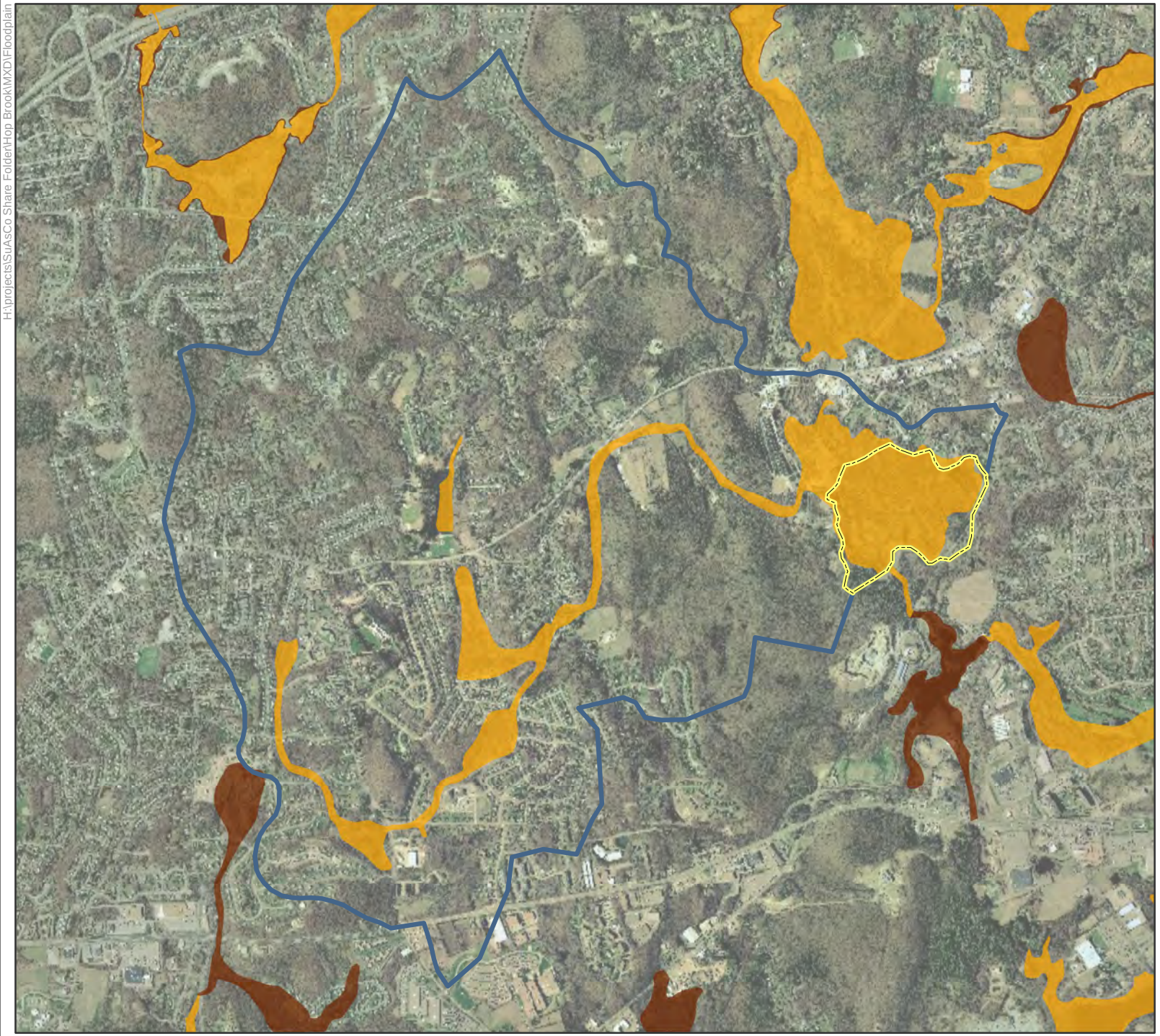
H:\projects\SuAsCo Share Folder\Hop Brook\MXD\Floodplain

SuAsCo: Hop Brook Dam

Figure 7. Floodplains



Legend

- 100yr Floodplain
- 500yr Floodplain
- Hop Brook Dam Project Area
- Hop Brook Dam Watershed

0 1,000 2,000 4,000

Feet

NRCS Natural Resources Conservation Service

Sources: AMEC, 2011; esri, 2006; FEMA, 1997

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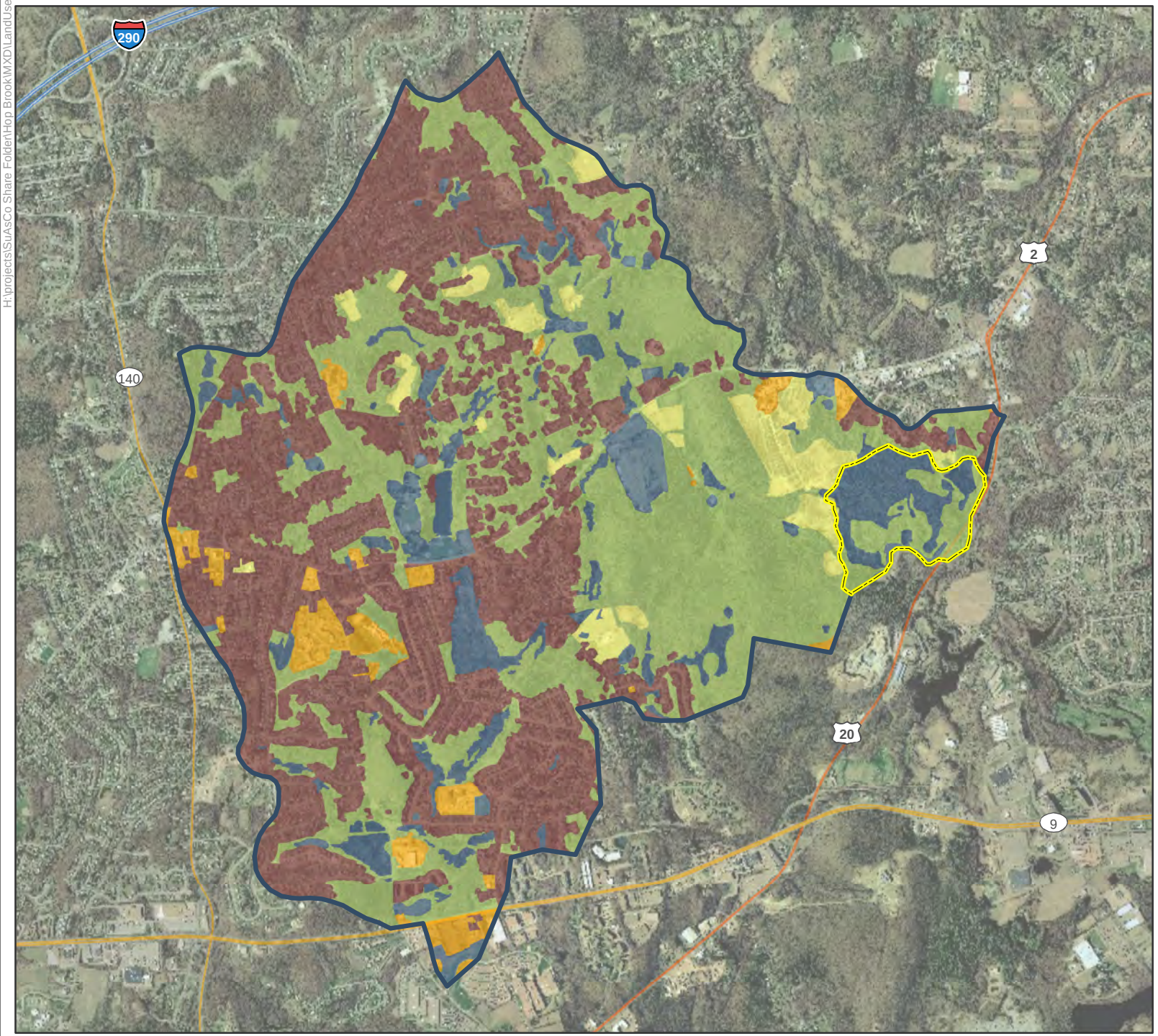
H:\projects\SuAsCo Share Folder\Hop Brook\MXD\LandUse

SuAsCo: Hop Brook Dam

Figure 8. Current Land Use in the Drainage Area



Legend

- Hop Brook Dam Project Area
- Hop Brook Dam Watershed

Land Use Category

- Agriculture
- Developed Industrial/Commercial
- Developed Residential
- Forest
- Other

0 1,000 2,000 4,000

Feet

NRCS Natural Resources Conservation Service

Sources: AMEC, 2011; esri, 2006; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, 2008-09; Sanborn, 2009; U.S. Census Bureau, 2010

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H:\projects\SuAsCo Share Folder\Hop Brook\MXD\Floodplain_LU_Downstream

SuAsCo: Hop Brook Dam

Figure 9. Current Land Use in the Downstream Floodplain

Legend

- 100yr Floodplain
- 500yr Floodplain
- Hop Brook Dam Project Area
- Hop Brook Dam Watershed

Land Use Category

- Agriculture
- Developed Industrial/Commercial
- Developed Residential
- Forest
- Other

0 250 500 1,000

Feet

NRCS Natural Resources Conservation Service

Sources: AMEC, 2011; esri, 2006; FEMA, 1997; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, U.S. Geological Survey (USGS), National Geospatial-Intelligence Agency (NGA) and Fugro Earthdata, Inc., 2009

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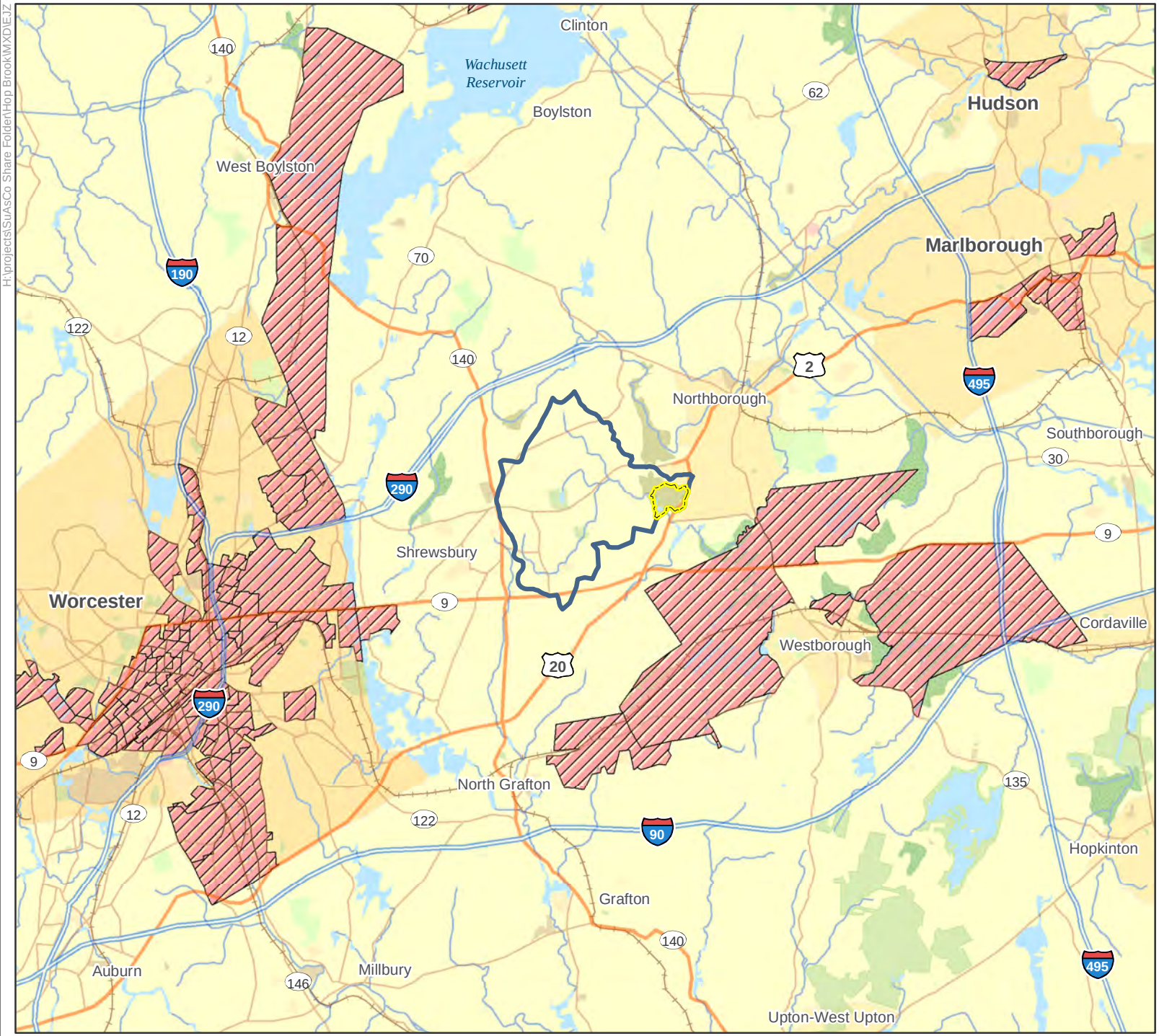
H:\projects\SuAsCo Share Folder\Hop Brook\MXD\EJZ

SuAsCo: Hop Brook Dam

Figure 10. Environmental Justice Zones



Legend

- Environmental Justice Zone
- Hop Brook Dam Project Area
- Hop Brook Dam Watershed

0 0.5 1 2

Miles

Sources: AMEC, 2011; esri, 2006; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, 2003; U.S Census Bureau, 2000

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Sub-appendix C-2:

Engineering Plans

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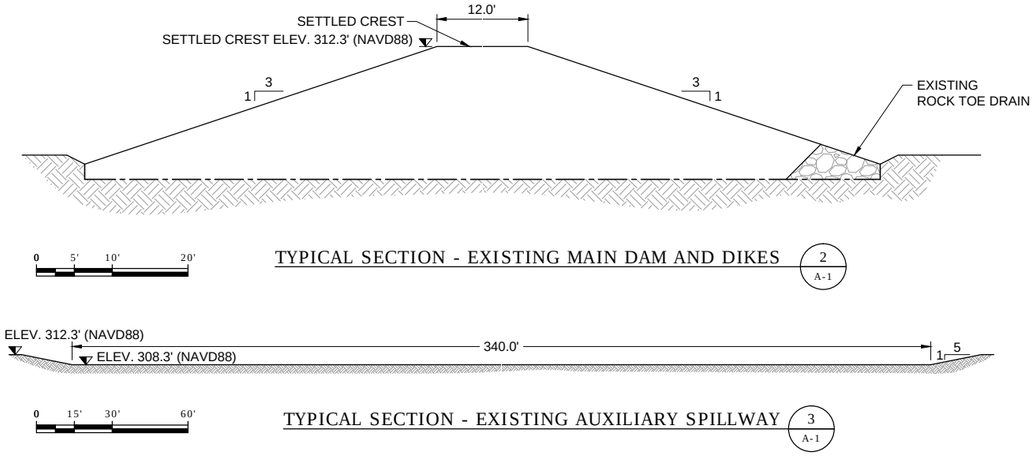
0 25' 50' 100'

LAYOUT PLAN - MAIN DAM, DIKE "A", AND DIKE "B" (1 / ####)



Rev.	Description	Date
4	Updated Final Submission	04.16.12
3	Updated Final Submission	03.28.12
2	Updated Final Submission	10.20.11
1	Final Submission	10.05.11
0	Issued For Comments	05.24.11

Designed JVB
Drawn SPM
Checked PM
Approved JVB

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Westford, Massachusetts 01886
Telephone: (978) 692-9090
Fax: (978) 692-6633
Web: www.amec.com

Hop Brook Floodwater Retarding Dam Rehabilitation Alternatives

EXISTING CONDITIONS
MAIN DAM, DIKE A & B
Hop Brook, Northborough, Worcester County, Massachusetts

United States Department of Agriculture Natural Resources Conservation Service
NRCS

Drawing No.
A-1

Sheet 1 of 6

Plot Time 2:59 PM
Save Time 2:58 PM
File Name Hop Brook Alternatives.dwg

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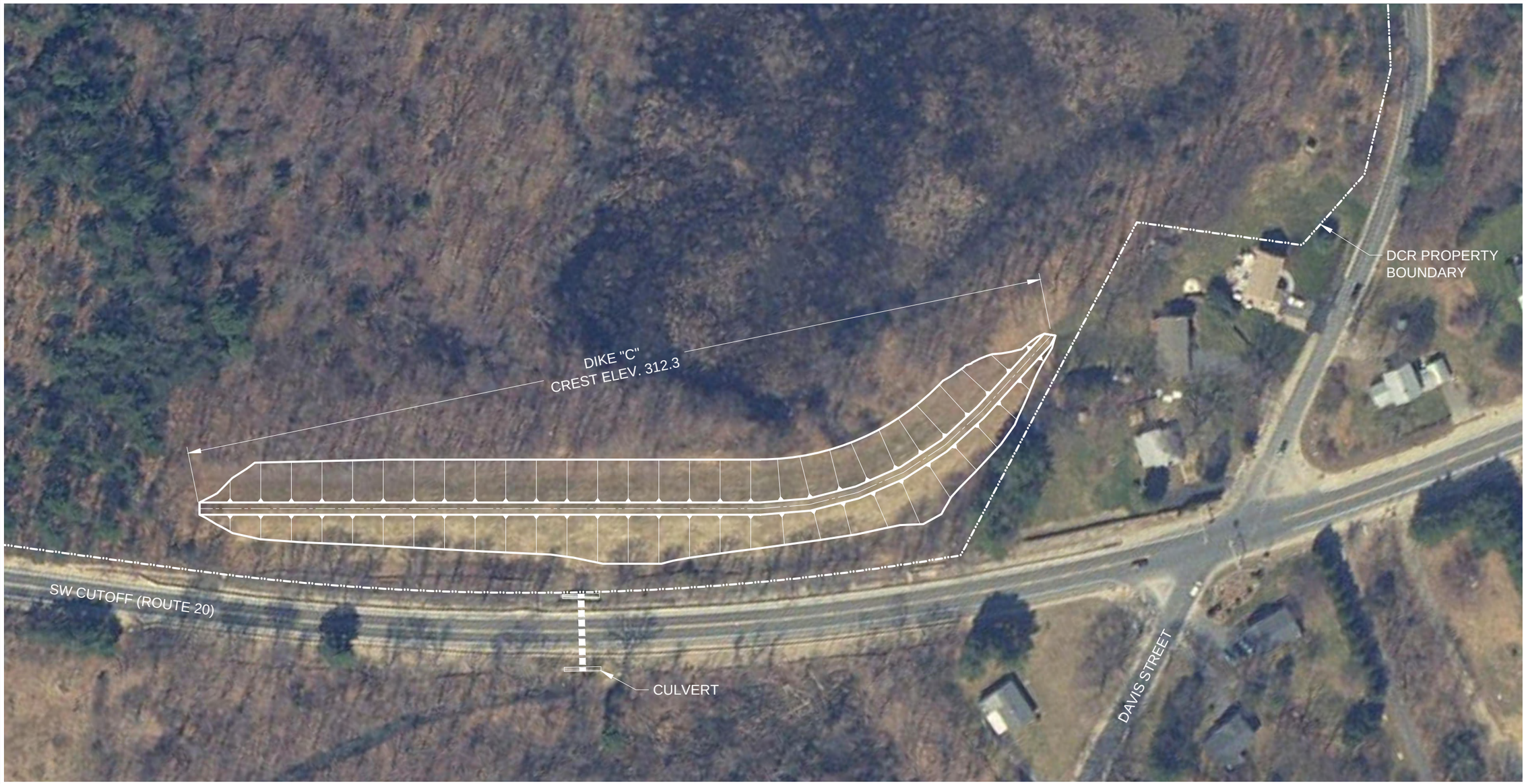
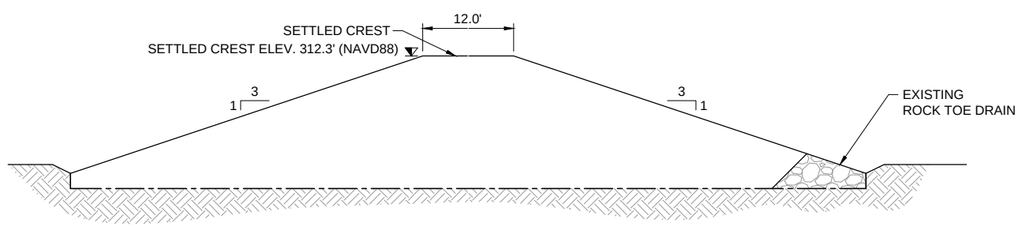


0 25' 50' 100'

LAYOUT PLAN - DIKE "C" 1 A-2



0 5' 10' 20'

TYPICAL SECTION - EXISTING MAIN DAM AND DIKES 2 A-2

Plot Time 2:59 PM
Save Time 2:58 PM
File Name Hop Brook Alternatives.dwg

Designed	JVB
Drawn	SPM
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Approved	JVB

Rev.	Description	Date
4	Updated Final Submission	04.16.12
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Hop Brook Floodwater Retarding Dam Rehabilitation Alternatives

EXISTING CONDITIONS
DIKE C

Hop Brook, Northborough, Worcester County, Massachusetts

United States Department of Agriculture Natural Resources Conservation Service NRCS

Drawing No.
A-2

Sheet 2 of 6

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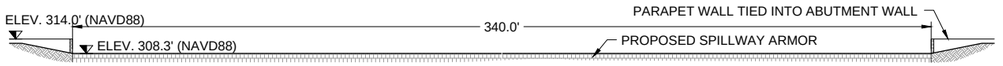


0 15' 30' 60'

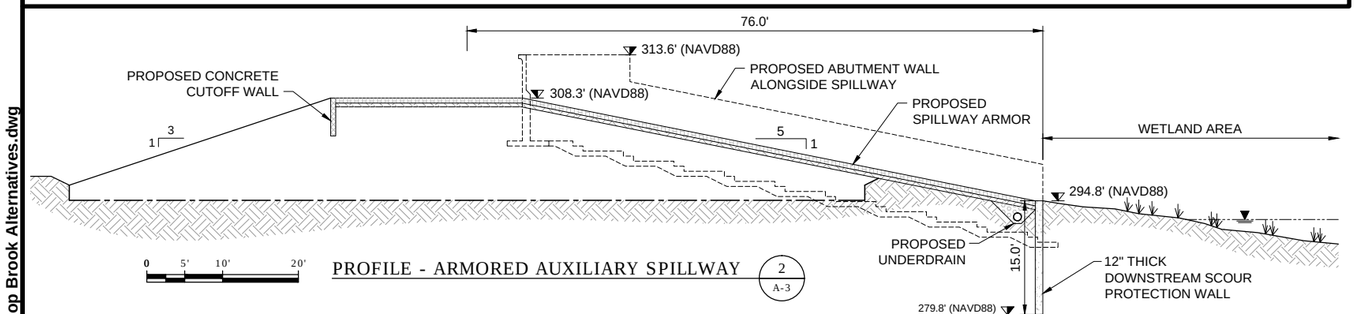
TYPICAL SECTION - ARMORED AUXILIARY SPILLWAY 4 / A-3

N 0 25' 50' 100'

LAYOUT PLAN - MAIN DAM, DIKE "A", AND DIKE "B" 1 / ####

0 5' 10' 20'

TYPICAL SECTION - MAIN DAM AND DIKE "A" 3 / A-3



0 5' 10' 20'

PROFILE - ARMORED AUXILIARY SPILLWAY 2 / A-3

	Designed	Drawn	Checked	Approved
	JVB	SPM	PM	JVB

Rev.	Description	Date
4	Updated Final Submission	04.16.12
3	Updated Final Submission	03.28.12
2	Updated Final Submission	10.20.11
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Hop Brook Floodwater Retarding Dam Rehabilitation Alternatives

ALTERNATIVE 1

PARAPET WALL, RAISED DIKES, AND ARMORED SPILLWAY WITH CUTOFF WALL

Hop Brook, Northborough, Worcester County, Massachusetts

United States Department of Agriculture Natural Resources Conservation Service NRCS

Drawing No. **A-3**

Sheet 3 of 6

Plot Time 2:59 PM

Save Time 2:58 PM

File Name Hop Brook Alternatives.dwg

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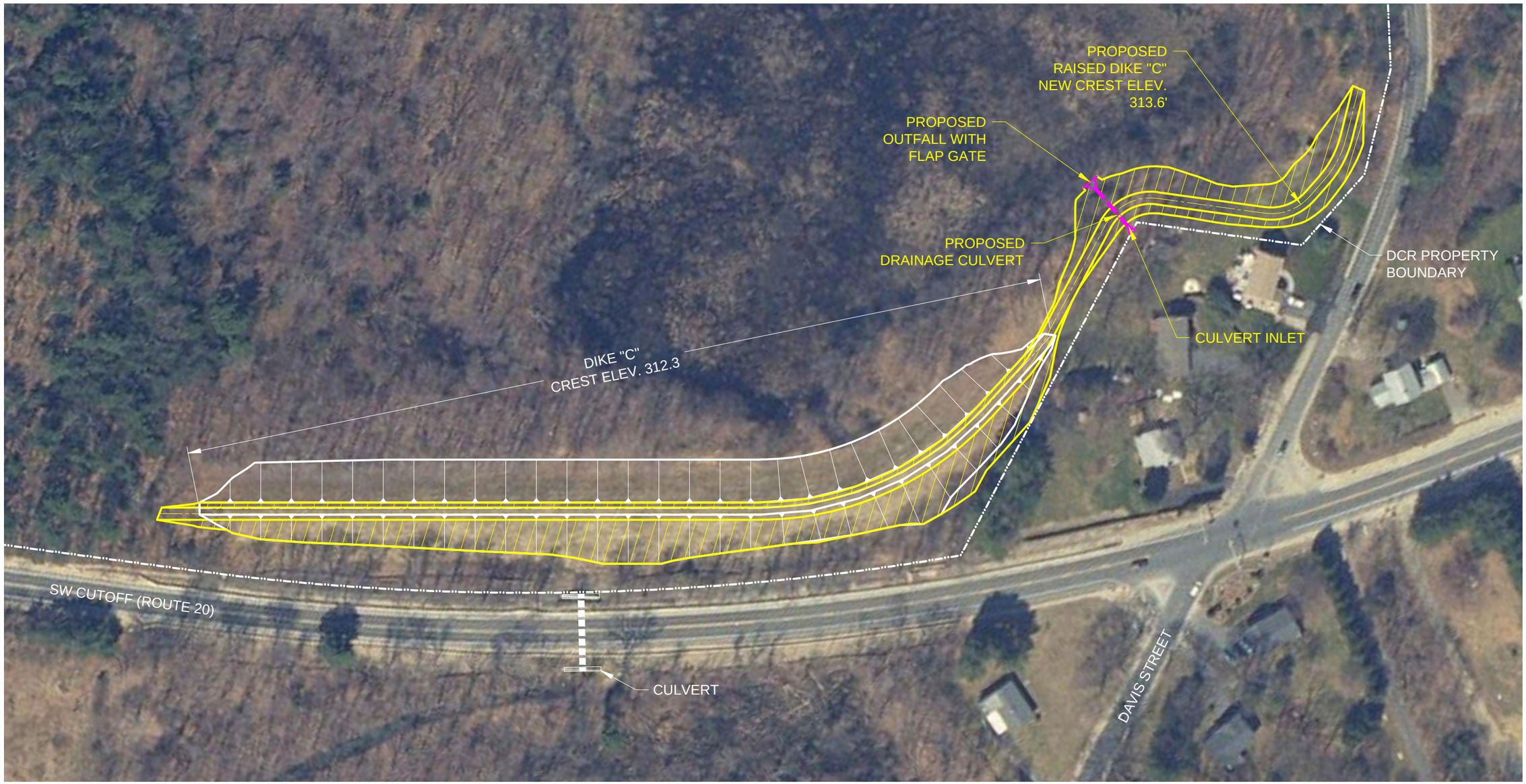
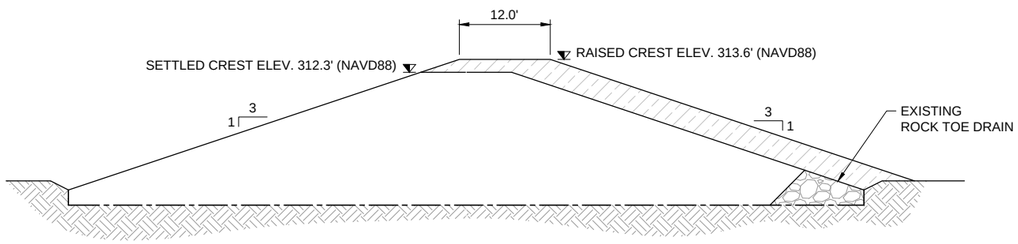


0 25' 50' 100'

LAYOUT PLAN - MAIN DAM, DIKE "A", AND DIKE "B" (2) 1 / ####



0 5' 10' 20'

TYPICAL SECTION - RAISED DIKES "B" AND "C" 2 / A-4

Rev.	Description	Date
4	Updated Final Submission	04.16.12
3	Updated Final Submission	03.28.12
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Hop Brook Floodwater Retarding Dam Rehabilitation Alternatives

ALTERNATIVE 1
PARAPET WALL, RAISED DIKES,
AND ARMORED SPILLWAY WITH CUTOFF WALL
Hop Brook, Northborough, Worcester County, Massachusetts

United States Department of Agriculture
Natural Resources Conservation Service
NRCS

Drawing No.
A-4

Sheet 4 of 6

Plot Time 3:00 PM
Save Time 2:58 PM
File Name Hop Brook Alternatives.dwg

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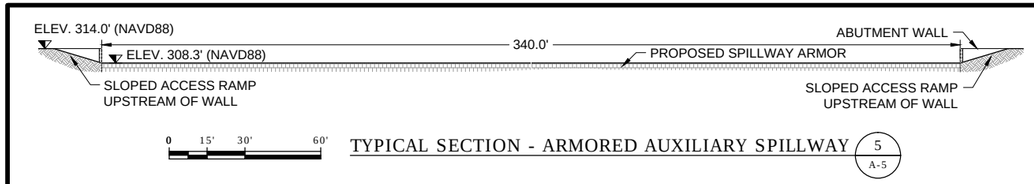
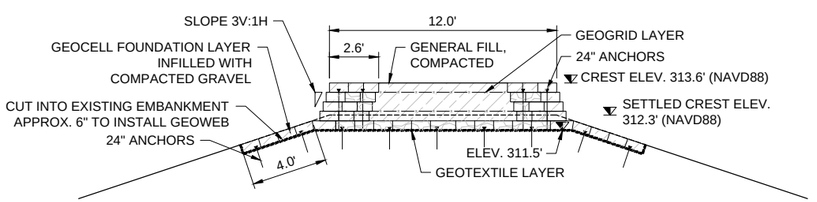


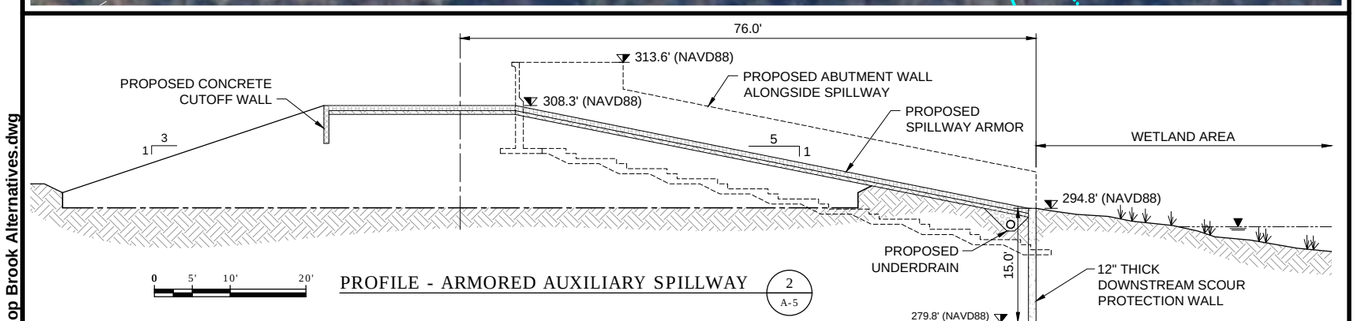
TYPICAL SECTION - ARMORED AUXILIARY SPILLWAY (5 / A-5)

LAYOUT PLAN - MAIN DAM, DIKE "A", AND DIKE "B" (1 / ####)

TYPICAL SECTION - MAIN DAM AND DIKE "A" (3 / A-5)



TYPICAL SECTION - GEOCELL WALL (4 / A-5)



PROFILE - ARMORED AUXILIARY SPILLWAY (2 / A-5)

Designed	JVB
Drawn	SPM
Checked	PM
Approved	JVB

Rev.	Description	Date
4	Updated Final Submission	04.16.12
3	Updated Final Submission	03.28.12
2	Updated Final Submission	10.20.11
1	Final Submission	10.05.11
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Hop Brook Floodwater Retarding Dam Rehabilitation Alternatives

ALTERNATIVE 2
GEOCELL WALL, RAISED DIKES,
AND ARMORED SPILLWAY WITH CUTOFF WALL
Hop Brook, Northborough, Worcester County, Massachusetts

United States Department of Agriculture
Natural Resources Conservation Service
NRCS

Drawing No.
A-5

Sheet 5 of 6

Plot Time 3:00 PM
Save Time 2:58 PM
File Name Hop Brook Alternatives.dwg

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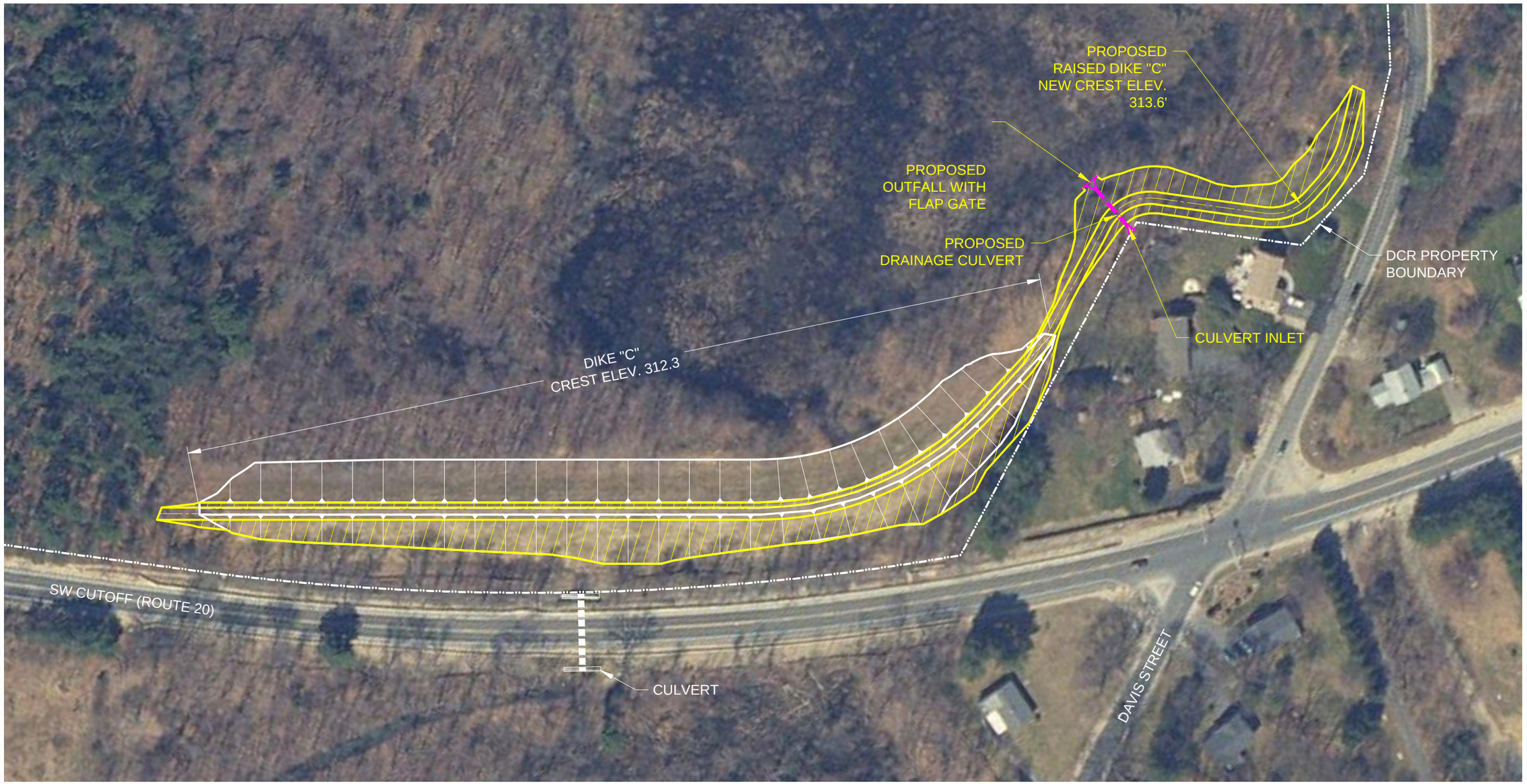
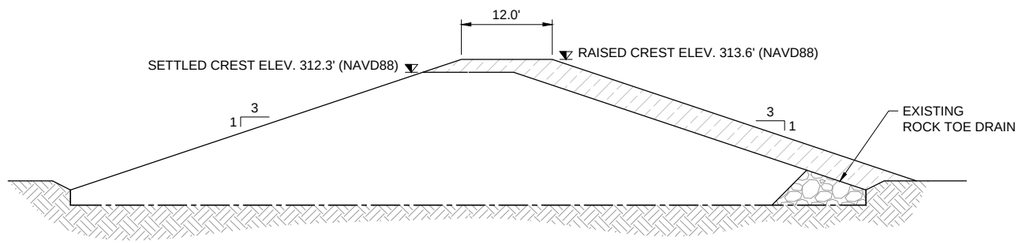


0 25' 50' 100'

LAYOUT PLAN - MAIN DAM, DIKE "A", AND DIKE "B" (1 / ####)



0 5' 10' 20'

TYPICAL SECTION - RAISED DIKES "B" AND "C" (2 / A-6)

Designed	JVB
Drawn	SPM
Checked	PM
Approved	JVB

Rev.	Description	Date
4	Updated Final Submission	04.16.12
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Hop Brook Floodwater Retarding Dam Rehabilitation Alternatives

ALTERNATIVE 2
GEOCELL WALL, RAISED DIKES,
AND ARMORED SPILLWAY WITH CUTOFF WALL
Hop Brook, Northborough, Worcester County, Massachusetts

United States Department of Agriculture
Natural Resources Conservation Service
NRCS

Drawing No.
A-6

Sheet 6 of 6

Plot Time 3:00 PM
Save Time 2:58 PM
File Name Hop Brook Alternatives.dwg

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Sub-appendix C-3:

Breach Inundation Maps

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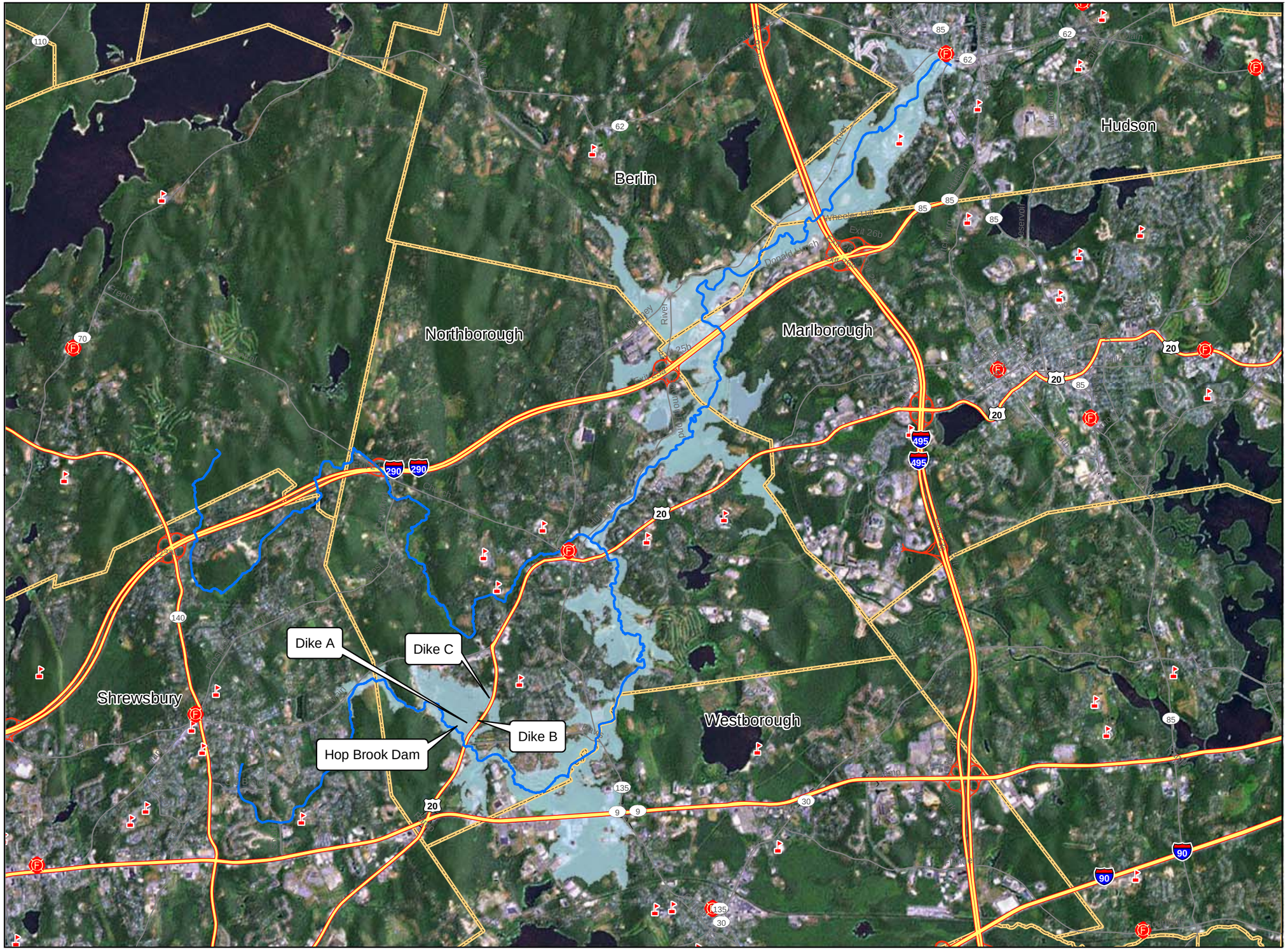
Structures Within the PMP Breach Inundation Zone

HOP BROOK DAM



Legend

- Town Boundary
- Highways
- Main Roads
- Stream
- PMP Breach Inundation Zone
- Fire Station
- Public School

*There are no Hospitals, Colleges/Universities, or Police Stations located in the inundation zone.

Location of Project Site

Notes and Sources

Notes: Imagery provided by ESRI.

N

0 2,150
Feet

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H:\NRCS\Northborough_MA\Task1\MXD\StructuresWithinPMPZone.mxd August 12, 2011 DWN: JDP CHKD: PM

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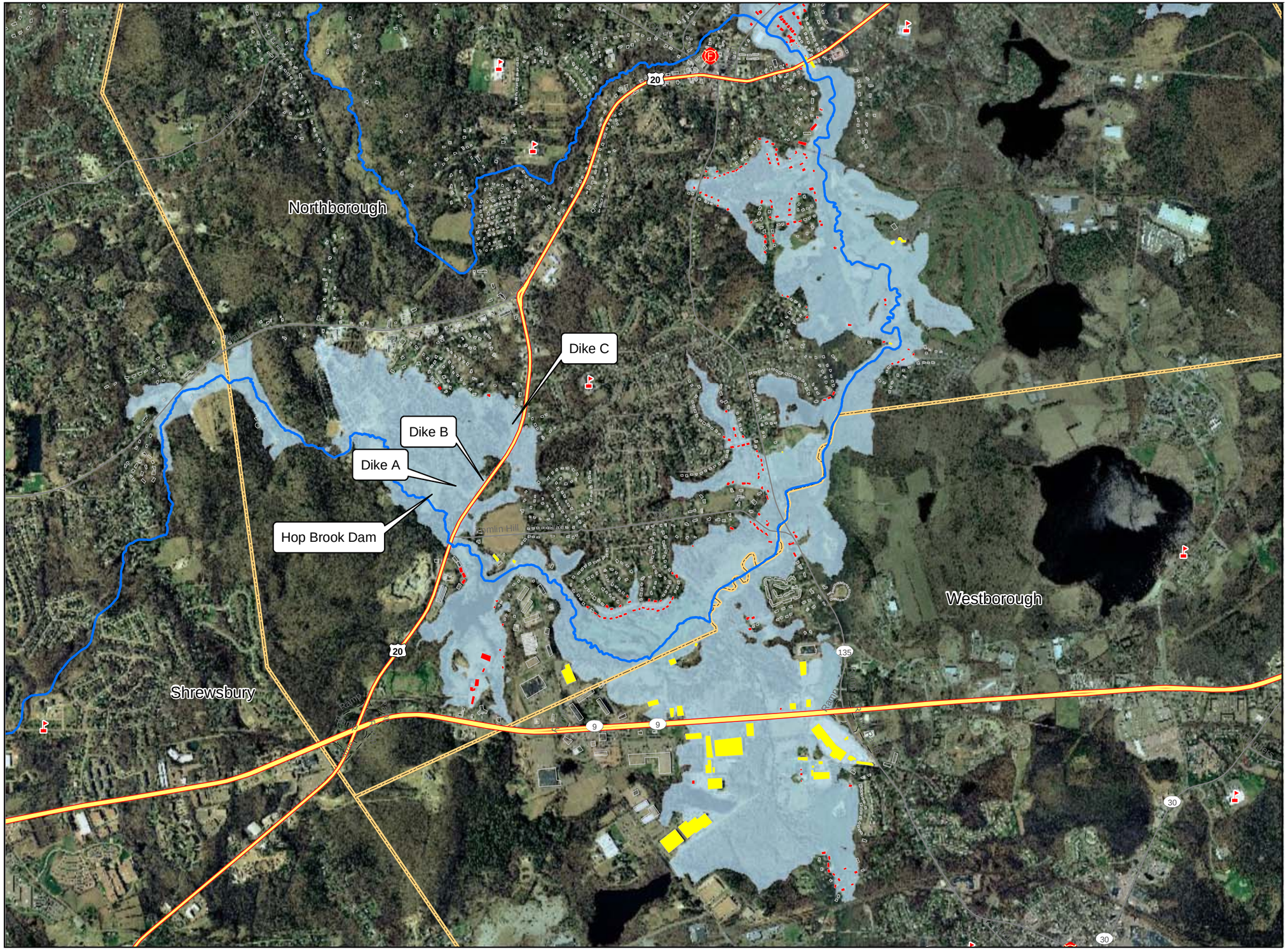

Structures Within the PMP Breach Inundation Zone

HOP BROOK DAM

Legend

- Residential Buildings
- Non-Residential Buildings
- All Other Buildings
- Town Boundary
- Highways
- Main Roads
- Stream
- PMP Breach Inundation Zone
- Fire Station
- Public School

*There are no Hospitals, Colleges/Universities, or Police Stations located in the inundation zone.

Location of Project Site

Notes and Sources

Notes: Imagery provided by ESRI.

N

0 2,000 Feet

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(978) 692-9090

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Structures Within the PMP Breach Inundation Zone

HOP BROOK DAM

Legend

- Residential Buildings
- Non-Residential Buildings
- All Other Buildings
- Town Boundary
- Highways
- Main Roads
- Stream
- PMP Breach Inundation Zone
- Fire Station
- Public School

*There are no Hospitals, Colleges/Universities, or Police Stations located in the inundation zone.

Location of Project Site

Notes and Sources

Notes: Imagery provided by ESRI.

N

0 2,000 Feet

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2 Robbins Road
Westford, MA 01886
(978) 692-9090

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Structures Within the PMP Breach Inundation Zone

HOP BROOK DAM

Legend

- Residential Buildings
- Non-Residential Buildings
- All Other Buildings
- Town Boundary
- Highways
- Main Roads
- Stream
- PMP Breach Inundation Zone
- Fire Station
- Public School

*There are no Hospitals, Colleges/Universities, or Police Stations located in the inundation zone.

Location of Project Site

Notes and Sources

Notes: Imagery provided by ESRI.

N

0 2,000 Feet

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APPENDIX D

INVESTIGATION AND ANALYSIS REPORT

Clean Air Act: The Clean Air Act[22] regulates air pollutants at the national level. The 8-hour Ozone Nonattainment Area State/Area/County Report (EPA 2011) was reviewed to determine if the site was within any of the 8-hour nonattainment areas designated by the U.S. Environmental Protection Agency (EPA), which it is. Additionally, the Massachusetts 2010 Air Quality Report (DEP 2011) was reviewed to determine the existing conditions of the air quality in the vicinity of the site. Furthermore, the project was reviewed to analyze potential air quality impacts that may occur as a result of the dam rehabilitation. It was determined that only minor, temporary impacts related to construction-related activities would occur which would result in a limited decrease in air quality during construction. Once construction has been completed, it is expected that existing air quality will resume to the current existing conditions.

Clean Water Act / Waters of the U.S.: The Clean Water Act[23] (CWA) applies to waters of the U.S. which generally refers to waters (i.e., rivers, lakes, etc.) that are traditionally navigable and their adjacent and contributing waters (i.e., streams, wetlands, etc.) Typically, projects are most often affected by the CWA under Section 401 and Section 404. In summary, Section 401 prohibits the degradation of water quality by regulated activities; Section 404 regulates the discharge of dredged or fill material into waters of the U.S.

As part of the planning process for the rehabilitation of the dam, Massachusetts Geographic Information Systems (MassGIS) (MassGIS 2009) and National Wetlands Inventory (NWI) (FWS 2009a) wetlands data was overlain on the project area to determine if there were any mapped wetland habitats in the vicinity of the dam. An infield site assessment was completed to determine the presence of any wetlands or other waters of the U.S. within the proposed project area in order to "ground truth" the wetlands mapping. As a result, several wetlands and waterscourses were identified within the vicinity of the site. These potentially regulated areas were overlaid onto the proposed engineering plans to determine if there would be any significant impacts to those resources as a result of the dam rehabilitation.

It was determined that rehabilitation of the dam will result in minor, temporary impacts likely less than 1 acre as well as minor, permanent impacts, likely less than 1 acre as a result of construction due to construction access and other construction-related activities. The water quality of Hop Brook may be affected by temporary construction-related disturbance resulting in erosion and sedimentation. Compliance with state laws, application of best management practices (BMPs), and revegetation of the disturbed area would minimize these impacts. As such, it is likely that the project will require a Section 401 Water Quality Certificate from the Massachusetts Department of Environmental Protection (DEP) and a Section 404 Programmatic General Permit (PGP) Permit from the U.S. Army Corps of Engineers (USACE).

[22] 42 U.S.C. 7401 *et seq*.
[23] 33 U.S.C. §1251 *et seq*.

Coastal Zone Management: Massachusetts's Coastal Management Program consists of enforceable programs and management principles which govern activities within a coastal zone. The Massachusetts coastal zone is generally restricted to land within 0.5 miles of coastal waters and salt marshes as well as all islands.

To evaluate the potential effects of dam rehabilitation on Coastal Zone Management areas, data from the Massachusetts Ocean Resources Information System (MORIS) was reviewed (MassGIS 2008a). The review indicated that the dam is not within any Coastal Zone Management areas.

Coral Reefs: The dam is located over 30 miles inland from the nearest coastal waters in Boston, Massachusetts. Since the dam is not in the vicinity of any coastal waters, it was determined that rehabilitation of the dam will not result in any impacts to coral reefs. Given the dam's inland locale, further consideration of impacts to coral reefs is not warranted.

Cultural Resources: The National Register of Historic Places (National Register) (NPS, 2011) was reviewed to determine the presence of any places listed or eligible for listing on the National Register. No places listed or eligible for listing in the vicinity of the dam were identified. Additionally, the Massachusetts State Historic Preservation Office (SHPO) and the Tribal Historic Preservation Office (THPO) were both consulted regarding the presence of known historic and cultural resources at the site. The SHPO indicated that there are no historic sites on the dam property, and no archeological sites would be affected by construction, which would be limited to the existing disturbed area with a determination of no effect on historic resources on November 17, 2011. A response was not received from the THPO.

Economic Analysis: The Natural Resources Conservation Service's (NRCS) National Watershed Program Manual (NRCS 2009) and the National Watershed Program Handbook (NRCS 2010) were used as references for the economic analysis along with two economic analysis guidance documents: Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) (WRC 1983) and the Economics Handbook, Part II for Water Resources (NRCS 1998). These guidance documents were used to evaluate potential flood damages, and estimate project benefits and associated costs. P&G was developed to define a consistent set of project formulation and evaluation instructions for all federal agencies that carry out water and related land resource implementation studies. The basic objective of P&G is to determine whether or not benefits from proposed actions exceed project costs. P&G also requires that the "National Economic Development" or NED Alternative, which maximizes monetary net benefits, be selected for implementation unless there is an overriding reason for selecting another alternative based on federal, state, local or international concerns related to the social and environmental accounts. The allowance for exceptions to the NED plan recognizes the fact that not all project considerations or benefits can be quantified and monetized when it comes to some ecological system and social effects.

Per sections 1.7.2(a)(4)(ii) and 2.1.1(b)(2) of the P&G allowing for abbreviated procedures, damage reduction benefits have not been estimated because they are the same for both alternatives, and no net change in benefits occurs when comparing the two candidate plans to each other. The federally assisted alternative (Alternative 2) is displayed within a zero-based accounting context that credits local costs avoided (Adverse, annual) as beneficial costs

(Beneficial, annual) consistent with P&G 1.7.2(b)(3). Net benefits are zero because the total project cost is equal to the claimed benefits and the resulting B/C ratio is 1.0:1.0.

Positive benefits would accrue as a result of this project as compared to existing conditions, but no attempt was made to compute an estimate of the difference between the future with project and existing conditions because the existing conditions are not the most likely future conditions. The added details would not alter the recommended alternative and, therefore, would not justify the added planning costs. Project flood-prevention benefit estimates were updated to 2011 dollars from the 1958 watershed plan. The Consumer Price Index (CPI) was used for updating reduction benefits for roads and bridges. Original downstream damage reduction benefits for residential and commercial properties were updated using the average increase in tax receipts. Values for selected commercial properties that constitute a major portion of the benefit calculations were updated to reflect current market values. These benefit estimates were not used to compare alternatives, because both alternatives provide the same benefit, but they show the ongoing value to the Commonwealth of Massachusetts and the local towns of the flood prevention provided by Hop Brook Dam.

All costs of installation and operation and maintenance were based on 2011 prices. One year was assumed for development, review, and approval of the final design and installation of the proposed rehabilitation project. Structural measures were assumed to have a 54-year useful life. Thus, a 55-year period of analysis was used along with the mandated 4.00 percent discount rate for all federal water resource projects for FY11 to discount and amortize the anticipated streams of costs and benefits.

Endangered and Threatened Species: Initial assessment of potential environmental impacts was based on review of natural resources information in MassGIS and consultations with U.S. Fish and Wildlife Service (FWS) and Massachusetts Natural Heritage and Endangered Species Program (NHESP). The FWS's list of Federally Listed Endangered and Threatened Species in Massachusetts (FWS 2009b) was reviewed to determine the potential presence of any federally-listed threatened or endangered (T&E) species in the vicinity of the site. As such, it was determined that there are no federally-protected threatened or endangered species in the project area. The NHESP's Priority Habitat for Rare Species (MassGIS 2008b) and Estimated Habitat for Rare Species (MassGIS 2008c) datasets were reviewed for the presence of rare species or their suitable habitats in the vicinity of the dam. As such, the wood turtle (*Glyptemys insculpta*), a Massachusetts species of Special Concern, is known occur in the vicinity of the dam as noted by the NHESP. As such, a field survey to identify possible suitable habitat for wood turtles in proximity to the dam was completed. The survey found that suitable habitat for wood turtles existed downstream of the dam, but the suitable habitat was located outside of the potentially affected project area.

Engineering: NRCS contracted AMEC Earth and Environmental, Inc. to complete engineering studies of the Hop Brook Dam. Several alternatives were screened out from further analysis because of cost, constructability, or environmental impacts:

- Decommissioning
- Relocation
- Floodwalls
- Increase height of dam and armor auxiliary spillway
- Increase width of existing auxiliary spillway
- Channel and Overbank Improvements Downstream
- Reducing the FBH Design Storm

Structural alternatives evaluated in detail were:

- Increase Height of Dam with a Parapet Wall and Armor the Auxiliary Spillway
- Increase Height of Dam with a Geocell Wall and Armor the Auxiliary Spillway
- Armoring the Auxiliary Spillway with ACBs

In 2011, AMEC performed additional engineering studies and the results indicate that raising the elevation of the existing earthen embankment along with armoring the auxiliary spillway is the only feasible alternative due to tailwater submergence conditions at the auxiliary spillway. These conditions reduce the effectiveness of auxiliary spillway capacity improvements (i.e. widening, labyrinth spillway, etc.) to freely pass the freeboard hydrograph (FBH) without overtopping the dam. Conveyance improvements downstream of the dam, needed to reduce FBH tailwater elevations to below the auxiliary spillway crest, were also evaluated but found not to be feasible.

Breach Analysis – A comprehensive hydrologic and hydraulic analysis was performed to evaluate the capacity of the Hop Brook Dam under current and build-out conditions. The analysis included development of several hydrologic and hydraulic models to predict maximum water surface elevations under a series of design storms. Design storms were established based on NRCS design criteria for earthen dams. The primary tool used for the evaluation of the existing capacity and rehabilitation alternatives was the NRCS's beta-test version of the WinDAM B computer model, intended to replace the Site Analysis Integrated Development Environment (SITES) model in the near future. Inflow hydrographs for the model were developed by modeling different rainfall scenarios in a HEC-HMS model and routing the hydrographs in a HEC-RAS unsteady-state model.

Results of the analysis indicate that under current and build-out conditions the dam does not meet the principal spillway capacity criteria because the 10-day drawdown requirement is not met during the passage of the principal spillway hydrograph (PSH). In addition, the analysis indicates that tailwater reduces the effectiveness of the auxiliary spillway to freely pass the FBH without overtopping the dam. The dam is overtopped under existing and potential future watershed build-out conditions by 0.99 feet and 1.12 feet, respectively. Consequently, the dam does not meet the design freeboard criteria since it does not allow for passing of the FBH without overtopping the dam.

Stability (surface erosion potential) and integrity (breaching potential) of the auxiliary spillway were also evaluated by routing the stability design hydrograph (SDH) and FBH, respectively. The results of the analysis indicate that under current and build-out conditions concentrated

flows will likely develop during the passage of design storms, ultimately resulting in severe headcut erosion and likely breaching of the auxiliary spillway.

The HEC-RAS computer program and its Dam Breach component were used to perform breach analysis of the dam during a PMF flood event. Breach parameters were estimated using empirical formulas developed by Xu and Zhang (2009). The unsteady-flow model was used to route PMF flows through the Hop Brook Dam and predict breach wave progression along Hop Brook and the Assabet River following a hypothetical dam breach. The results of analysis predict that a breach of Hop Brook Dam would occur 5.54 hours from the beginning of the PMP event and would result in maximum discharge of 10,015 cubic feet per second (cfs) through the breach opening. The peak flows associated with the PMF breach event are expected to be an order of magnitude greater than the 100-year flood event for Hop Brook and the Assabet. Maximum water surface elevations resulting from the breach wave progression were used to estimate inundation areas downstream of the dam.

Environmental Justice: MassGIS data (2003) depicting Environmental Justice Zones was reviewed to determine if there were any zones within close proximity to the dam. The data shows that there are no Environmental Justice Zones in the vicinity of the project site.

Essential Fish Habitat: To analyze whether rehabilitation of the dam will impact essential fish habitat, National Oceanic and Atmospheric Administration's (NOAA) Essential Fish Habitat Mapper[24] was reviewed. The mapper shows that there is no essential fish habitat within close proximity to the dam. As such, further analysis regarding potential impacts to essential fish habitat is not warranted.

Floodplain Management: The 100-year floodplain (MassGIS 1997) was reviewed to determine what, if any, impacts rehabilitation of the dam would have on the floodplain. As a result of the review, it was determined that rehabilitation of the dam will likely not impact the downstream floodplain. In fact, because the rehabilitation will bring the dam into federal and state dam safety guidelines and standards, the downstream floodplain will benefit from the rehabilitation. The rehabilitation will reduce the potential of the dam from failing. Failure of the dam would result in high velocity flows through the auxiliary spillway and downstream of the dam which would likely cause heavy erosion and sedimentation of the downstream floodplain.

Hydrology: NRCS prepared an assessment report on the Hop Brook Floodwater Retarding Dam in 2005, based on a dam assessment study by the Bhatti Group (2005). The Bhatti Group completed a comprehensive study of the hydrologic conditions of the Hop Brook Dam for existing and future watershed build-out conditions. The study evaluated the hydrological parameters of the Hop Brook watershed using NRCS and TR-55 methods, with NRCS runoff curve numbers for existing and future build-out conditions of 73 and 78, respectively, and a time of concentration of approximately 4 hours.

Using the SITES model, Hop Brook was evaluated against TR-60 criteria and was determined to be a high hazard structure in accordance with federal standards and a high hazard potential

[24] NOAA Essential Fish Habitat Mapper. Available [online]: <http://sharpfin.nmfs.noaa.gov/website/EFH_Mapper/map.aspx>. Accessed October 5, 2011.

structure in accordance with Massachusetts standards. The Principal Spillway Storm was the 100-year frequency with a 10-day storm duration. The Auxiliary Spillway Design Storm used a precipitation amount greater than the 100-year event and less than the Probable Maximum Precipitation (PMP) and a 6-hour design storm for developing the Auxiliary Spillway Hydrograph. The 2005 Dam Assessment Report indicated that the Hop Brook Flood Control Structure does not meet TR-60 design criteria for the freeboard and auxiliary spillway design under existing or the future build-out conditions. In general, the spillway is undersized.

The SITES model results indicated that under both the existing and future watershed build-out conditions, the exit velocity in the existing auxiliary spillway would cause the vegetative cover to fail, concentrated flow to develop, and the spillway to breach during both the SDH and FBH design storms.

Invasive Species: During infield investigations, plant communities were identified throughout the site. In particular, the presence of invasive species was noted. As a result of the infield investigations, several invasive species including common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and reed canary grass (*Phalaris arundinacea*). Although the presence of invasive species was noted at the site, they were observed in only sporadic clusters. In order to reduce the potential of construction activities transporting invasive species material to or from the site, best management practices will be employed to ensure that rehabilitation of dam does not spread invasive species material.

Migratory Birds / Bald and Golden Eagle Protection Act: The Migratory Birds Treaty Act[25] seeks to protect migratory birds. As such, the law makes it illegal to pursue, hunt, take, capture, kill or sell protected birds. The Bald and Golden Eagle Protection Act[26] prohibits the "taking" of bald and golden eagles.

During the infield investigations, numerous species of migratory birds where observed. However, it is likely that these species will not be harmed as a result of dam rehabilitation. The majority of the project impacts will occur on the dam itself (i.e., embankments, spillways, dikes, etc.). These areas are routinely mowed and do not provide suitable habitat for migratory species. It is likely that migratory species that may be affected by rehabilitation of the dam will relocate to other areas adjacent to the proposed project area during construction. Once construction has been completed, it is expected that those species will return to the area.

There is no suitable habitat for bald (*Haliaeetus leucocephalus*) or golden eagles (*Aquila chrysaetos*) at the site. Additionally, the bald eagle is a state-listed endangered species. If bald eagles were known to occur in the vicinity of the site, the NHESP would have identified such an occurrence during their project review. As such, it is highly unlikely that the project would affect any bald or golden eagles.

Plants: During the infield site investigation, vegetative communities were noted as they occurred throughout the site. Plant species in each vegetative community were noted. The majority of the site consists of upland forests and wetland habitats.

[25] 16 U.S.C. §§703-717
[26] 16 U.S.C. 668-668d

Construction activity would likely result in minor impacts affecting the vegetation due to the installation of the proposed armoring of the auxiliary spillway and raising of the embankment and dikes. However, at the completion of construction, equipment would be removed and the disturbed area would be restored.

Prime and Unique Farmlands: The list of Prime and other Important Farmland Soils (NRCS 2007) was reviewed to determine what soils are considered to be prime or unique farmland soils in Worcester County, Massachusetts. Soil mapping data resources (NRCS 2007) were reviewed to determine the extent of any prime and/or unique farmland soil mapped on the site.

In total, there are 1,801 acres of prime and unique farmland soils mapped in the drainage area of the dam. In the downstream floodplain, 1,577 acres of prime and unique farmland soils are mapped.

Riparian Areas: Riparian areas are generally described as habitats that exist in the vicinity of the interface between watercourses and land. In order to determine the extent of riparian areas in the vicinity of the dam, available watercourse mapping data (MassGIS 2000) was reviewed to identify areas on the site where riparian areas likely existed. During infield investigations, these areas were traversed to determine the condition of riparian habitat in the vicinity of the dam.

Riparian areas were identified along the banks of the Hop Brook. In general, these areas consisted of forested floodplain, forested wetland, and upland forest habitat.

Sedimentation: A walking survey of the Hop Brook flood storage area confirmed that there is minimal sediment accumulation from the past 45 years. Previous minor accumulations at the principal spillway have been removed by the Massachusetts Department of Conservation and Recreation (DCR) during routine maintenance.

During a field inspection of the pool area by Rudy Chlanda, a NRCS geologist, it was noted that minimal sediment has been delivered to the sediment pool. The soils and geology in the drainage area are granular with low clay/silt percentage. Due to hummocky glacial topography, much of the sediment would not be transported to stream channels. Wetlands adjacent to the stream capture much of the sediment. The streams are low gradient. There are two ponds above the pool, Hop and Eaton, which have served as sediment "traps". The stream buffers developed to satisfy the Massachusetts Wetlands Protection Act do an excellent job of reducing sediment.

Since surveying the pool would amount to several weeks of surveying and staff time, it was decided to revisit the original sedimentation estimate in the 1958 Plan. Three estimates were prepared by Mr. Chlanda, using NRCS Form 309 based on three scenarios:

1. A revision of the original 1954 estimate, which was based on the probable soil loss formula. It is likely that this outdated methodology overestimated the sediment. Forty-six years was used to estimate sediment accumulation to date.
2. A second estimate uses present land use acres developed by AMEC from the dam assessment.

3. A third estimate, based on build-out of the watershed through its extended service life of 54 years, was developed using 20 years as the present and 34 years for future build-out.

Values Used for Soil Loss – The values used for soil loss came from NRCS references, a reference from the NRCS District Conservationist (D. Lenthall), Natural Resources Inventory (NRI) data for Cultivated Land, NRI data and observation for Pasture/Range, Woodland, Meadow, and from observation and web references for Urban Lands, with judgment applied based on the percentage of impervious surfaces.

The calculated delivery ratio was 23 percent, which was reduced to 20 percent based on the presence of at least two ponds in the watershed that trap sediment. Average values were checked for annual sediment deposition in New England from the Reservoir Sedimentation (RESSED) database. Values range from 0.04 acre feet/mile² in Connecticut to 0.15 acre feet/mile² in Maine. Hop Brook average annual deposit is 0.03 acre feet/mile² which compares favorably with a similar sized dam in Connecticut (0.04 acre feet/mile²).

The estimated sediment volume for 46-year history of the dam is 11.5 acre-feet. The estimated sediment volume for the remaining 54 years of project life is 8.6 acre-feet. The total of 20.1 acre-feet is still 1.9 acre-feet less than the sediment volume predicted for design. Hop Brook Dam has more than ample sediment storage available for its predicted service life and beyond.

Scoioeconomics: Sources for the data included in the social and economic conditions section of this supplement include the U.S. Census Bureau, Department of Commerce, 2000 and 2010 Census, and interviews conducted with local contacts.

Soil: NRCS (2007b) soil mapping data for Worcester County, Northeastern Part, Massachusetts was reviewed to determine the soil types mapped in the vicinity of the dam. Review of the soils mapping for site shows that several major soil types are mapped in the area of dam. Richfield, Merrimac, Agawam, and Canton fine sandy loams constitute over 50 percent of the soils in the Hop Brook Dam area. The poorly drained Freetown muck represents over 20 percent of the dam area. Other soils exist in the area of the dam which are mapped in densities less than 20 percent of the land area.

Wetlands: A field survey was conducted by EA Engineering, Science, and Technology, Inc. (EA) to identify and assess wetlands upstream and downstream of the dam in the potential construction area. Wetlands identified include Bordering Vegetated Wetlands, Land Under Water Bodies, Banks, and Rivers.

Based on the surveys and the conceptual project design, most of the construction for dam rehabilitation would occur within the existing area previously disturbed for construction of the dam and maintained as mowed grass. However, some wetland impacts are likely occur as a result of construction, access, and minimal permanent wetland impacts may occur as result of the armoring of the auxiliary spillway.

Wild and Scenic Rivers: The Wild and Scenic Rivers Act[27] established the National Wild and Scenic Rivers System. To determine if any Wild and Scenic Rivers were present in the vicinity of the dam, the River Mileage Classification for Components of the National Wild and Scenic Rivers System (NPS 2011b) was reviewed. According that list, the Assabet River (of which the Hop Brook is a tributary) is listed. The section of the Assabet River is located downstream of the dam from 1,000 feet downstream of the Damon Mill Dam to its Confluence with the Concord River. This section of the river, approximately 4.4 miles, is located completely within the Town of Concord, Massachusetts.

The following table displays the effects of the recommended plan on particular types of resources that are recognized by certain Federal policies.

Effects of the Recommended Plan on Resources of National Recognition		
Types of Resources	**Principal Sources of National Recognition**	**Measurement of Effects**
Air quality	Clean Air Act, as amended (42 USC 7401 et seq.)	No long-term effect; temporary emissions during construction
Areas of particular concern within the coastal zone	Coastal Zone Management Act of 1972, as amended (16 USC 1451 et. seq.)	Not applicable--project area not in coastal zone.
Endangered and threatened species critical habitat	Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.)	No effect—no federally protected species in project area
Fish and wildlife habitat	Fish and Wildlife Coordination Act (16 USC Sec. 661 et seq.)	No effect—project would not involve work in stream/river.
Floodplains	Executive Order 11988, Flood Plain Management	No long-term effect; temporary construction in floodplain.
Historical and cultural properties	National Historic Preservation Act of 1966, as amended (16 USC Sec. 470 et seq.)	No effect—no historic resources present in project area
Prime and unique farmland	Council on Environmental Quality Memorandum of August 1, 1980: Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing the National Environmental Policy Act, Farmland Protection Policy Act of 1981.	No effect—construction only within areas which have been previously disturbed by dam construction.
Water quality	Clean Water Act of 1977 (33 USC 1251 et seq.)	No long-term effect; temporary impact during construction mitigated by erosion and sediment control BMPs

[27] 16 U.S.C. 1271-1287

Effects of the Recommended Plan on Resources of National Recognition		
Types of Resources	**Principal Sources of National Recognition**	**Measurement of Effects**
Wetlands	Executive Order 11990, Protection of Wetlands; Clean Water Act of 1977 (33 USC 1251 et seq.) Food Security Act of 1985	Less than 1 acre of impacts; possible temporary impact during construction; area returned to existing condition after construction
Wild and scenic rivers	Wild and Scenic Rivers Act, as amended (16 USC 1271 et seq.)	No effect – there are no wild or scenic reivers present in the project area

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APPENDIX E

OTHER SUPPORTING INFORMATION

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Sub-appendix E-1:

Consultation and Public Scoping Process

Stakeholder agencies that were contacted concerning the proposed project are:

- Worcester County Conservation District
- Massachusetts Department of Conservation and Recreation
- Massachusetts Department of Fish & Game, Division of Fisheries and Wildlife
- Massachusetts Department of Fish & Game, Riverways Program
- Massachusetts Department of Environmental Protection
- Town of Northborough (Selectmen, Conservation Commission, Planning Board, Engineering)
- Town of Northborough Trails Committee
- Organization of the Assabet River
- Massachusetts Executive Office of Energy and Environmental Affairs
- Massachusetts Executive Office of Energy and Environmental Affairs, MEPA
- EPA Region 1, Regulatory
- USACE, Regulatory Division
- Massachusetts Office of Dam Safety

The SHPO concurred with the determination that the proposed project will not impact any historic resources. Coordination with THPO of the Wampanoag Tribe of Gay Head (Aquinnah) is currently ongoing. Any response from THPO will be included in subsequent drafts of this plan.

A "no species present" letter was obtained from the FWS, which indicates that no federally listed threatened or endangered species are known to occur within the area. It was determined from MassGIS that habitat for a state-protected species lies in the Hop Brook floodplain. Subsequent consultation with Massachusetts NHESP indicated that a state-listed species of concern, the wood turtle, has been found in the area.

A public meeting was held in the Town of Berlin on May 24, 2011, to explain the Watershed Rehabilitation Program, obtain public input on the project, and scope resource problems, issues, and concerns of local residents associated with the Hop Brook Dam project area. The meeting was widely advertised to reach everyone in the watershed including minorities. NRCS distributed a press release on May 6, 2011, that resulted in an article about the meeting in the MetroWest Daily News on May 25, 2011.

Potential alternative solutions to bring the Hop Brook Dam into compliance with current dam safety criteria were presented at the public meeting. A fact sheet summarizing the planned rehabilitation projects at six dams in the SuAsCo watershed was distributed at the meeting. Two members of the public attended the meeting; no verbal or written comments were received at the meeting or in the intervening time to the publishing of this Plan.

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Sub-appendix E-2:

Regulatory Correspondence

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United States Department of the Interior

FISH AND WILDLIFE SERVICE

New England Field Office
70 Commercial Street, Suite 300
Concord, NH 03301-5087
http://www.fws.gov/newengland

January 3, 2011

To Whom It May Concern:

This project was reviewed for the presence of federally-listed or proposed, threatened or endangered species or critical habitat per instructions provided on the U.S. Fish and Wildlife Service's New England Field Office website:

(http://www.fws.gov/newengland/EndangeredSpec-Consultation.htm)

Based on the information currently available, no federally-listed or proposed, threatened or endangered species or critical habitat under the jurisdiction of the U.S. Fish and Wildlife Service (Service) are known to occur in the project area(s). Preparation of a Biological Assessment or further consultation with us under section 7 of the Endangered Species Act is not required.

This concludes the review of listed species and critical habitat in the project location(s) and environs referenced above. No further Endangered Species Act coordination of this type is necessary for a period of one year from the date of this letter, unless additional information on listed or proposed species becomes available.

Thank you for your cooperation. Please contact Mr. Anthony Tur of this office at 603-223-2541 if we can be of further assistance.

Sincerely yours,

Thomas R. Chapman
Supervisor
New England Field Office

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Commonwealth of Massachusetts

Division of Fisheries & Wildlife

MassWildlife

Wayne F. MacCallum, *Director*

October 20, 2011

P. Chase Bernier
EA Engineering, Science and Technology
2374 Post Road, Suite 102
Warwick RI 02886

RE: Project Location: Hop Brook - Northborough
Town: NORTHBOROUGH
NHESP Tracking No.: 08-25393

To Whom It May Concern:

Thank you for contacting the Natural Heritage and Endangered Species Program ("NHESP") of the MA Division of Fisheries & Wildlife for information regarding state-listed rare species in the vicinity of the above referenced site. Based on the information provided, this project site, or a portion thereof, is located **within** *Priority Habitat 452* (PH 452) and *Estimated Habitat 347* (EH 347) as indicated in the *Massachusetts Natural Heritage Atlas* (13th Edition). Our database indicates that the following state-listed rare species have been found in the vicinity of the site:

Scientific name	Common Name	Taxonomic Group	State Status
Glyptemys insculpta	Wood Turtle	Reptile	Special Concern

The species listed above is protected under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 131A) and its implementing regulations (321 CMR 10.00). State-listed wildlife are also protected under the state's Wetlands Protection Act (WPA) (M.G.L. c. 131, s. 40) and its implementing regulations (310 CMR 10.00). Fact sheets for most state-listed rare species can be found on our website (www.nhesp.org).

This evaluation is based on the most recent information available in the NHESP database, which is constantly being expanded and updated through ongoing research and inventory. If you have any questions regarding this letter please contact Lauren Glorioso, Endangered Species Review Assistant, at (508) 389-6361.

Sincerely,

Thomas W. French

Thomas W. French, Ph.D.
Assistant Director

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The Commonwealth of Massachusetts
William Francis Galvin, Secretary of the Commonwealth
Massachusetts Historical Commission

November 17, 2011

P. Chase Bernier
Project Scientist
EA Engineering Science & Technology Inc.
2374 Post Road Suite 102
Warwick RI 02886

RE: Hop Brook Dam Rehabilitation, Northborough, MA. MHC #RC.24431.

Dear Mr. Bernier:

Staff of the Massachusetts Historical Commission, office of the State Historic Preservation Officer, have reviewed the information that you submitted for the project referenced above, for raising the embankment and dikes, extending Dike C, and adding an abutment wall to the auxiliary spillway for erosion protection.

Review of the MHC's Inventory of Historic and Archaeological Assets of the Commonwealth identified no inventoried historic or archaeological resources.

The MHC does not recommend additional identification effort for the project.

The MHC recommends that the Natural Resource Conservation Service make a finding of "no historic properties affected" (36 CFR 800.4(d)(1)) for the undertaking.

These comments are offered to assist in compliance with Section 106 of the National Historic Preservation Act of 1966 as amended (36 CFR 800). Please contact Edward L. Bell of my staff if you have any questions.

Sincerely,

Brona Simon
State Historic Preservation Officer
Executive Director
Massachusetts Historical Commission

xc:
Thomas Akin, NRCS
Northborough Historical Commission

220 Morrissey Boulevard, Boston, Massachusetts 02125
(617) 727-8470 • Fax: (617) 727-5128
www.sec.state.ma.us/mhc

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